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JOURNAL OF DAIRY SCIENCE

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AMERICAN DAIRY SCIENCE ASSOCIATION

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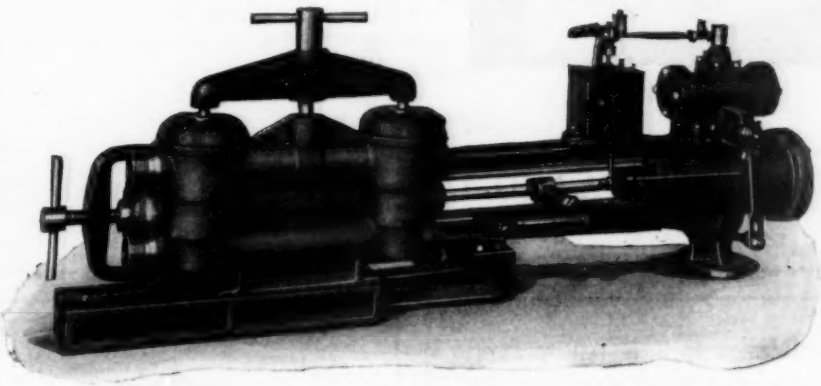

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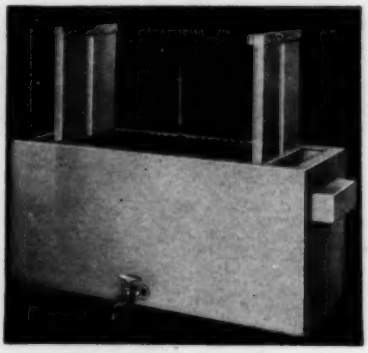

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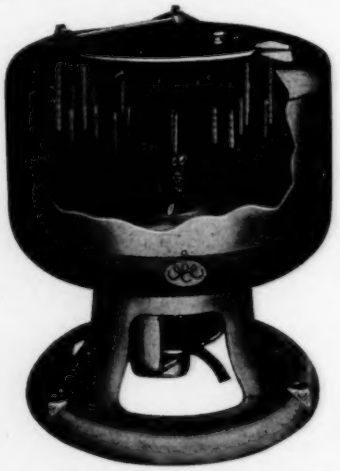

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EXTENSION ACTIVITIES AND THEIR RELATION TO THE COLLEGE AND THE EXPERIMENT STATION

A. A. BORLAND

Dairy Husbandry Department, State College, Pennsylvania

Received for publication March 15, 1923

There appears to be a wide diversity in the relation of the extension service to the college of agriculture and the experiment station in different states throughout the union. In some institutions the authority is decentralized so that the duties of the dean of the college of agriculture, the director of the experiment station, and the director of the extension service are vested in as many different persons. Likewise supervision of the resident instruction and the experimental work in dairying is divorced to a considerable extent from that of the dairy extension activities, although in practically all cases the teaching of the extension work is expected to be in accord with that of the resident instruction.

In other states the authority is centralized and the dean of the college of agriculture is the director of the experiment station and also the director of the extension service. He may be assisted by a vice-dean of the college of agriculture, an assistant director of the experiment station and an assistant director of the extension service. Where the authority is thus centralized the head of the dairy husbandry department is responsible for the teaching, the investigation and the extension work in dairying, so that the department is the unit for these various lines of activity. The head of the department makes recommendation for the appointment not only of instructors and investigators but also of extension specialists. The latter are attached to the various departments in exactly the same way as teachers and investigators. The head of the department supervises the planning of the extension work, keeps the extension workers in touch with the research work and has general control except for administrative matters such as finances and the itinerary of the

men. Between these two forms of organization there are a considerable number of combinations.

Which of these types of organization is best or whether any one type is best is difficult to say. Each plan seems to be working well in the particular States where it is in use although some members of the staff in certain States have stated frankly that they believe a different form than that now in use in their State would be an improvement. I shall bring to your attention some of the thoughts that have been expressed concerning the advantages of the various forms of organization and I trust that the consideration of the whole subject will be helpful in enabling us to render the best possible service to the people of our respective States.

Those who favor a separate organization for carrying on the agricultural extension work of the state, wherein the different lines of activities such as dairy husbandry, animal husbandry, agronomy, and horticulture are headed by extension specialists, responsible to the head of the resident instructional and experimental work only in that the teaching in the field is to be in accord with that of the department, feel that the departmental head who already is dividing his time between teaching and research cannot advantageously divide his time and effort still further in order to give attention to a line of work that is different and distinct from those already under his direction.

Furthermore, the director of extension should feel the responsibility for seeing that the maximum amount of work is performed by the specialists in the different lines, and on their part the specialists will take a greater interest in their work and will be likely to get better results if they plan and direct the work and are held responsible for it than if some one less closely associated with the work directed it.

If the animal husbandman, the dairyman and the agronomist had the direction of the specialists in these lines, the extension director might find difficulty in accomplishing the special things he has in mind. They might differ in their opinion as to what lines of work should receive increased attention. A particularly ambitious man in one line of work might want most of the funds available put into his projects.

The resident teaching staff is not able to keep so closely in touch with the problems of the field as the extension specialists themselves. The latter consequently are in better position to plan and put across a strong program of work in the field than are the resident instructors.

As one director puts it:

Extension work must be projected in a community, county, or in the state, with a definite program, based on the agricultural needs of the community, county or state, and adapted to the local agricultural needs and home life of the community. In other words, this program must get closer to the needs of the respective communities of the State. In developing this program, the farm and farm home must be considered more and more as a unit, and the various lines of work so correlated as to make the farming and home life of these farms more profitable. Therefore, each line of work must have its proper place in the farm management scheme of the individual farm or the social and economic welfare of the community. In times past extension work has been largely projected by individual demonstrations in dairying, livestock, fruit growing, potato growing, etc., said demonstrations being conducted on farms and in communities, without any relation to each other. This form of demonstration work while it was helpful and a necessary step in the development of extension work that would have to be undergone to bring extension work to its present level, has profitably served its purpose: But the time has come when the farm must become the demonstration unit, and these varied lines of work correlated into a farm management program for the particular farm or community. For example, assuming that we were going to develop beef cattle production in a certain community or on a certain farm, this would naturally appear to be an animal husbandry project. However, there must be forage and feed crops for these cattle, and the agronomist must assist in developing the program. It would be hard to say which is the more important: the animal husbandman or the agronomist—both are equally essential. Then, there may be a marketing problem which involves the help of a marketing specialist, and so on with other specialists which would enter into the development of this particular program.

Now, the extension director can visualize the program in a community or county, and correlate these various lines far better than the head of a departmental unit. Furthermore, it is a whole lot easier to correlate a group of specialists who are responsible to one head than it is for a

superintendent of extension to correlate the work of heads of departments who are not responsible to him, but rather are responsible to the dean of the college of agriculture or the director of the experiment station. Furthermore, the head of a departmental unit is by the very nature of the work largely interested in his particular subject and unconsciously is bound many times to be onesided and look at things with this kind of viewpoint. Often he is not thinking in terms of an agricultural program as a whole, but rather a part of it, and there is the possibility that due to his interest in his own particular line of work and his desire to see it developed, he may sell to a community or county something which they ought not to have, and which really does not fit into the community or county program. We have this happen periodically with specialists who are over-zealous in their work; they get out in counties and attempt to put over some particular piece of work for which the county or community is not specifically adapted, but which the people can readily be talked into wanting. Of course, such a project fails.

Then, too, many of the heads of our departmental units are research men or resident teaching men, whose work has kept them closely at the college or experiment station, with the result that they have not been out over the state much and do not know either the people or the agricultural needs of the state nearly so well as some head of an extension division whose business it is to be in touch with the people of the State and to be informed by personal contact with the agricultural needs of the various sections of the state, counties, and communities. It is my firm belief that no head of a department, either a research man or a resident teaching man, can develop a state-wide, constructive policy along his line of work unless he has had an opportunity for traveling the state and knows the practical needs of the various counties and communities. Therefore, his programs are not going to be as close to the people as we think necessary to make them practical. Extension work must get closer to the real needs of the people. This not only means that the subject matter presented to them must be more practical and adapted to their immediate needs, but also that the contacts must be closer and particularly the contacts of those who form the developmental policies of the respective lines of work carried on in various counties over the state.

Those who believe that the various departments of the college should have the three functions: teaching, research and

extension, and that the purely administrative matters such as the making up of schedules, the supervision of financial matters and the arrangement of conferences should properly be handled by the extension director base their claims on the fact that such a plan brings the workers of all phases of a certain activity together under one leadership which makes unity of teaching, promotes harmony and eliminates many of the problems of competition.

This arrangement keeps the extension men in close touch with the work that is being done in the department and keeps those in resident work in close touch with what is being done throughout the state. Neither has to depend on occasional conferences since by officing and working together they are constantly in touch with one another. An important part of the extension man's work is to carry out to the people on the farm the results of investigations in the department. This can better be done by having the extension specialist a member of the department rather than of a separate organization.

One director states:

> This institution has taken the position that resident teaching, extension teaching, and experiment station work are all phases of the same large problem, that of agricultural betterment. We have been inclined to believe that it is wise to have the college and experiment station staff in actual contact with the people of the state and their problems, and for this reason we have not been inclined to build up a large and independent body of extension specialists. We have, of course, had a few, but our feeling now is that even those, in most instances, should have a definite college and experiment station connection.
>
> The idea that the extension specialists can carry out, second hand, the so-called "bottled information" of the college and experiment station to the people and bring back and turn over, second hand, the problems which should be investigated by experiment station workers may be right in theory, but in practice it works out decidedly to the disadvantage of the college and experiment station workers who are, after all, and must always remain, the substantial sources of information for extension teaching.
>
> With all these facts in mind, we are, as far as practicable, asking our heads of departments to be responsible for resident teaching, for extension teaching and for investigation.

Another director adds this comment:

> We have here only one and not three departments for any one subject. The plan has worked exceedingly well thus far and is a great improvement over the old arrangement where each division was practically independent. Under such a system it was impossible to secure uniform teaching.
>
> We have stated conferences each quarter, at which all college, station and extension workers are present. All questions of college policy are threshed out at these conferences and there are also frequent discussions relative to what constitutes sound advice to the farmers of the state. The organization being departmental there is every opportunity for the college, station and extension workers within a department to keep in thorough touch with each other.

There is evidently much to be said in support of each type of organization and it may be added that the testimony from each of the forty-eight states is that the type of organization prevailing in that state is working well. As nearly as the writer can judge the following states, twenty-seven in number, carry on the extension work largely independent of the teaching and research heads except for an advisory capacity and the supervision of subject matter: Arkansas, Delaware, Florida, Georgia, Idaho, Kansas, Louisiana, Maine, Maryland, Minnesota, Mississippi, Nebraska, Nevada, New Hampshire, New Jersey, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Utah, Vermont, Washington and Wyoming.

Those in which the extension work, save for administrative matters, is handled largely within the several departments so that each department is the unit for teaching research and extension are twenty-one in number, as follows: Alabama, Arizona, California, Connecticut, Colorado, Illinois, Indiana, Iowa, Kentucky, Missouri, Montana, Michigan, Massachusetts, New York, New Mexico, North Carolina, Ohio, South Carolina, Virginia, West Virginia and Wisconsin.

METHODS EMPLOYED IN INFORMING EXTENSION WORKERS OF RESULTS OF EXPERIMENTAL WORK IN PROGRESS AT THE EXPERIMENT STATIONS

One of the dangers of extension work is that on account of the large demands for service in the field, meetings, conferences, demonstration work and the like, the extension worker finds but little time for reading and for keeping up to date concerning the results of the most recent investigations in his line of work. The extension worker cannot afford either for his own sake or for that of the people he serves to neglect keeping himself abreast of the times. Most extension directors specifically suggest that the specialists spend at least one day per week at headquarters for the purpose of conferences, office work and the keeping in touch with the latest developments in their respective lines of work either at their own experiment station or through the bulletins issued by other stations.

Some of the suggestions that have been made as to how the extension workers could best keep well informed are as follows:

Weekly departmental conference, at which time all members of the department, including station workers, college workers and extension men are are called in. At this time each division reports any progress of work in the department and the extension man reports any progress that is made in his work throughout the State.

The presentation of the experimental work in detail by the director of the experiment station before the extension staff yearly, or oftener.

The location of the extension men with the department in which they do their work.

The publication of a weekly agricultural news letter.

One institution expects the extension workers to remain at the college one week out of three. This gives them an opportunity to get in touch with the experimental work in progress and to keep in close association with those who are engaged in teaching and in experimental work.

In certain institutions the entire extension force visits the

different departments every two or three months. The head of the department presents the projects and tells of the progress being made in the various experiments under headway.

Special meetings are held at times when the experiments can best be inspected and lessons drawn from the work in progress. In Ohio a wheat day was held, when the matters of crop rotation, varieties and fertilization were discussed. The crops were in such a stage of maturity that lessons could best be drawn.

In some states a monthly news letter is sent out to the county agents and the extension representative. These write-ups give account of the experimental work in progress and afford opportunity for the resident instructional and experimental staff to place before farmers the latest results and lessons from experimental investigations.

KEEPING COLLEGE AND EXPERIMENT STATION WORKERS INFORMED AS TO THE PROBLEMS AND CONDITIONS IN THE STATE

College teachers and those engaged in research are just as likely to grow stale in certain directions as the extension worker. The local character of teaching and experimental work with the consequent lack of opportunity to get into first hand touch with the people of the state and their problems makes the teacher and the investigator constantly dependent on the extension worker for knowledge of the actual situation in the field and of the most pressing problems that call for investigation.

Many of the directors of experiment stations and extension service as well as heads of departments feel that where the department is the unit for the three lines of work and the extension workers are located with the department the organization itself naturally takes care of this problem since the teaching staff, the research men and the extension workers are intimately associated.

Some of the suggestions for keeping those engaged in resident work informed as to the situation in the field are the following:

At the beginning of the year the specialist prepares a plan for the year's work, which after approval by the head of the department, is placed in the hands of the dean of the college of agriculture. Quarterly reports are made of the work being done by

the extension specialists, from which the college can judge of the progress made by the extension agents in carrying out the plan of work for the year.

An attempt is made in some institutions to keep the resident workers in touch with extension matters by inviting the subject matter heads to take part in extension conferences, when programs of work are being formulated.

Members of the teaching and station staff are frequently informed regarding the problems in the state, through occasional farm visits and definite assignments to extension work, such as judging, demonstration and lecture work.

In some States the extension service holds a public conference every Monday morning, which is open to all those who care to attend. In other States these conferences are held once a month and the experiment station likewise holds a monthly conference to which the extension representatives are invited.

Copies of annual extension reports as well as various other reports are filed in one state with the chairman of the dairy department. In the future it is planned to file carbon copies for each trip report with him, so that the department may be kept posted with all information on field activities up to date. In other states a summary of the county agents and extension specialists weekly or monthly reports are prepared and sent to the college and station workers.

A unique publication is issued at one institution which contains statements dealing with teaching, research and extension. It represents the interests of the whole institution rather than of the extension department solely. The members of the staff are thus kept informed as to the progress in the different departments.

DIFFICULTIES

The problems are not all solved by any means. Many difficulties present themselves both to the college and experiment station workers as well as to the extension workers. The most common obstacles in the way of resident work appear to be a lack of money and equipment for teaching and research. The

extension man usually runs up against problems which need an immediate solution. Usually these problems cannot be solved by the experiment station immediately on account of the fact that other experiments may already be under headway. College dairy herds are not large enough to use on the very extensive experiments and this condition cannot be remedied except with an enlargement of the dairy activities of the college and the experiment station.

Some of the extension workers feel that the experiment station staff is devoting too much attention to problems that have long ago been solved either by the people of the state or by other experiment stations. In other words, they are running experiments that are not of present interest to the people. They feel that marketing, farm management and agricultural economics have not received their just portion of the experiment station's attention and that these are really the important present day problems on which they need the most help.

One criticism of teaching and research work has been that the commercial application is limited. In many cases the industry cares little for basic findings which bear in a general way on the industry. Scientific results are preferred which can be immediately applied and which will increase the returns and lessen the efforts of the dairy farmers of the state.

Another of the difficulties from the extension standpoint is in obtaining definite and usable information from the subject matter departments in such form that it may be used for extension meetings.

Extension work in most states has had more funds available than has research or college work. The result has been that extension work has out-run the other lines of activity and is calling for the solution of problems which the experiment station with its present facilities is not in position to undertake.

The successful teacher and research man is frequently drawn upon for so many talks and reports concerning his investigations that he finds his research work very much handicapped from the point of being able to devote a proper amount of time to it. There has been a feeling at times that the extension work gives

a better opportunity for acquaintanceship throughout the state, and for this reason college men are prone to neglect their resident work for some form or other of extension activity.

Regular class work interferes with extension work and if the men are taken out of classes to do extension work this seriously handicaps the instruction.

Men who give all of their time to instructional work some times feel that they are not making the progress for themselves that the station and extension workers are.

The director of one experiment station makes the following comment:

> All progressive members of our extension staff recognize that station research has not been keeping pace with the development of agricultural extension. The remedy lies in the employment of better trained research workers, a greater degree of coöperation in research at our institutions and more adequate financial support of station research.
>
> The difficulties that the college and station workers experience in their dealing with extension problems are concerned chiefly with the failure of the average extension worker to keep himself posted on the progress of agricultural research in this country and abroad. The average extension worker does not read and study sufficiently to be of the greatest value to his institution and to his constituency. Moreover, any college or station worker who shows progress in his chosen field is promptly appropriated by the extension service and ultimately is compelled to neglect his research, and at times even his teaching, to meet the needs of the extension service.

One extension specialist in dairying makes the following suggestion:

> My own personal opinion is, after four years' experience, that the future extension man must be first of all an investigator. He appreciates the problems in a much different way than does the man who is solely investigator. Then he must have the additional qualification of being able to present clearly to good audiences the results of his and of other investigations. Instead of so much lecturing, as he is now doing, he will go into the field and find out what the problems are and solve them if possible, because primarily the farmer is most interested in the solution of his problems.

The director of extension in another state comments as follows:

Some of the chief obstacles and difficulties from the extension point of view concerning the college and station work are, first, that the general agricultural public is not always interested and for that reason do not always support the work being done at the College and Experiment Station. This lack of support, I believe, is largely due to the fact that the general public or even the readers in agricultural affairs have no part in planning and determining of problems for investigation and research. I believe the way to overcome this difficulty is to secure the coöperation of all parties concerned before a problem of research is undertaken. The parties concerned here consist of the experiment station staff, the farmers, and the extension workers. These people should get together or their representatives, and discuss freely and carefully the problems that are most in need of solution and the ones that the farmers are most anxious to have solved. This will bring, I believe the interest and support of the farmers. The extension workers can assist the experiment station men in maintaining the proper contact with the field during the process of investigation. The research man will be more likely to keep his work more nearly in line with the immediate needs of agriculture and through the extension service can make the proper contacts with the farmers.

Something of the same difficulty obtains on the part of the research man with regard to the extension work as obtains on the part of the farmer with respect to research work. The investigator must know more about the farmers' point of view and be able to make better contacts with the field conditions in order for him to become thoroughly cognizant of the position and point of view of the extension workers.

The general consensus of opinion is that the chief difficulties between extension activities and college and station work result from the lack of a proper understanding and appreciation of the functions of the experiment station, the college of agriculture and the extension service. It is suggested that the teaching force, the investigators and the extension workers in a particular field of activity, such as dairying, have their offices in the same building, and that all workers be called together at frequent intervals to discuss problems in each line of work so as to promote common interest and mutual understanding.

Difficulties and misunderstandings may largely be eliminated by the employment of a satisfactory personnel in the three lines of work, and by establishing and maintaining close personal contacts between the different classes of workers. Personnel is of especial importance. The best of plans will fail in the hands of an inferior personnel, whereas an ordinary plan will be improved and made to work satisfactorily in the hands of the right kind of men. One of the principal qualifications of a satisfactory personnel is a sincere spirit and an honest desire to give good service and the absence of petty selfishness and over-sensitiveness about credit. There should be a mutuality of interests among college, station and extension men, each recognizing the function of the other and the impossibility of the exercise of any of these functions without common sense and wholesome relationship among the groups. We all need to be imbued with the spirit of unselfish public service.

We need to recognize that teaching, investigation and extension are component parts of one great organization for the improvement of agriculture and that the best way for each of us to get the most good from the organization is to do all in his power to make that organization a success.

A STUDY OF THE FACTORS THAT INFLUENCE THE COAGULATION OF MILK IN THE ALCOHOL TEST[1]

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The alcohol test is being used to some extent as a test for grading milk. The test is usually made by adding 2 cc. of milk to 2 cc. of alcohol in a test tube. The test tube is then closed with the thumb, inverted several times and examined. If no precipitate is formed the test is said to be negative, and if a precipitate is formed the test is said to be positive. The strength of the alcohol used is usually 68 or 70 per cent by volume.

When the test first came into use in 1890 it was regarded largely as a measure of acidity. However it was soon found that fresh milk from individual cows frequently coagulates and that the test was dependent upon other factors as well as upon acidity. Nevertheless the test was still used for it was thought that besides acidity it detected other undesirable characteristics. Thus Ernst (1) believed that a positive test of fresh milk was due to irritation of the milk glands. Ruhm (2), Rullman and Trommsdorf (3), and Campbell (4) claimed that a positive test was due to infected or diseased udders. Metzger (5) found that infection of the uterus and animals lean from disease caused a positive test. Auzinger (6) stated that milk from cows with infected vaginas and cows that had aborted was positive to the test. Henkel (7), Metzger (5) and Auzinger (6) found that colostrum milk influenced the test.

[1] Published with permission of the Director of Wisconsin Agricultural Experiment Station.

[2] The work presented in this paper constitutes the thesis of T. H. Binney, submitted in partial fulfillment of the requirements for the degree of Master of Science in the graduate school of the University of Wisconsin, 1922.

These various causes listed in the literature are only remote causes, they are operative only in so far as they affect the chemical composition and properties of the milk. As far as we are aware the only other direct causes mentioned besides acidity are the effect of rennet forming organisms studied by Ayers and Johnson (8), and the effect of the milk salts, especially calcium, observed by Auzinger (6).

Thus it is apparent that our knowledge of the direct causes for the alcohol coagulation is incomplete. It is the purpose of the work reported in this paper to determine the factors influencing the alcohol test and to study their relative importance.

METHOD USED

In this work both 70 and 75 per cent alcohol by volume were used. The alcohol used was distilled in the presence of sodium hydroxide to remove any acid which might be present. This distilled alcohol was then adjusted to the desired strength by the addition of distilled water. The strength was determined by means of the Westphal balance. The 70 per cent alcohol by volume was adjusted to a specific gravity of 0.8900 at 15°C. and the 75 per cent alcohol by volume to a specific gravity of 0.8773.

In each case, except where otherwise indicated throughout this work, 2 cc. of milk were added to 2 cc. of alcohol in a test tube. The test tube was then closed with the thumb, inverted several times and examined for the appearance of the precipitate. The mixtures were then very carefully examined and on the appearance of the slightest precipitate the tests were called positive. Any additional methods used in this work will be explained when the experiments in which they were used are discussed.

THE EFFECT OF MILK SALTS

It is a well known fact that electrolytes have a very marked effect on the stability of colloids, especially electrolytes that yield doubly and triply charged ions on dissociation. In the case of milk we are dealing with a colloidal solution of albumin

and casein in the presence of the milk salts containing the bivalent calcium and magnesium and the trivalent phosphate and citrate radicles. We would expect, then, that the stability of the milk proteins would be influenced by the amounts of these salts present. Van Slyke and Hart (9) and Van Slyke and Bosworth (10) actually found in working with calcium compounds of casein that the presence of small amounts of soluble calcium salts have a very marked effect upon the solubility of the casein compounds.

More recently it has been shown by Sommer and Hart (11) that the calcium and magnesium and the citrates and phosphates present in the milk have a very marked effect upon the heat coagulation of milk, as in the sterilization of evaporated milk. It was shown that there is a balancing effect between calcium and magnesium on the one hand, and the citrates and the phosphates on the other, the proper balance of these producing the most stable condition, an excess of either of these causing the milk to coagulate more readily on heating.

That the milk salts are also of importance in the alcohol test was indicated by the work of Auzinger (6). Working with the milk from three cows he was able to change the alcohol test from negative to positive by feeding each cow 120 grams of calcium phosphate per day. However, other investigators have continued to give other reasons for the test and as a result have either contradicted or obscured Auzinger's conclusions.

In order to determine experimentally what effect the various milk salts have on the alcohol test they were added to milk in varying amounts and the alcohol test applied. Fourth-molar solutions of calcium acetate, magnesium chloride, potassium chloride, di-potassium phosphate and sodium citrate were prepared and added to 25 cc. of fresh milk in a series, increasing the amounts of the salt solution by 0.1 cc. In each series the dilution was equalized by the addition of the proper amount of distilled water. The results are given in table 1. Table 1 shows that 0.2 cc. of M/4 calcium acetate and 0.1 cc. of M/4 magnesium chloride added to 25 cc. of fresh milk was sufficient to cause a positive reaction with the alcohol test. These addi-

tions are equivalent to an increase of 0.0112 and 0.0040 per cent CaO and MgO, respectively. As high as 0.9 cc. of M/4 potassium chloride, di-potassium phosphate, and sodium citrate were added to 25 cc. of milk and the milk still gave a negative test with alcohol.

The results show that a slight increase in the calcium or magnesium content of the milk will cause a positive reaction with the alcohol test, while an increase of potassium, sodium chloride, citrate and phosphate will not cause a positive test.

TABLE 1

Effect of salts on alcohol test

25 cc. milk plus	Water, cc.	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0	Strength of alcohol per cent by volume
	Solution, cc.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
M/4 calcium acetate		−*	−	+	+	+	+	+	+	+	+	75
		−	−	−	+	+	+	+	+	+	+	70
M/4 magnesium chloride		−	+	+	+	+	+	+	+	+	+	75
		−	−	+	+	+	+	+	+	+	+	70
M/4 potassium chloride		−	−	−	−	−	−	−	−	−	−	75
		−	−	−	−	−	−	−	−	−	−	70
M/4 di-potassium phosphate		−	−	−	−	−	−	−	−	−	−	75
		−	−	−	−	−	−	−	−	−	−	70
M/4 sodium citrate		−	−	−	−	−	−	−	−	−	−	75
		−	−	−	−	−	−	−	−	−	−	70

* Plus and minus signs indicate positive and negative alcohol tests respectively, under the conditions indicated in the table.

SALT BALANCE

In order to determine whether the effects of the milk salts on the alcohol test counteract each other in a manner similar to the salt balance demonstrated in the heat coagulation, the effect of various combinations of salts was studied.

Table 2 shows the results of the alcohol test on three different combinations of salts in varying proportions. Using the same fresh milk throughout the experiment three series of samples

were prepared. Each series consisted of ten portions of 25 cubic centimeters each. To each of the samples in all three series 0.5 cc. of M/4 calcium acetate was added. This was sufficient to make the alcohol test distinctly positive. To these three series M/4 di-potassium phosphate, potassium chloride,

TABLE 2

The effect of salts on the alcohol test

25 CC. MILK PLUS												STRENGTH OF ALCOHOL PER CENT BY VOLUME
	M/4 ACETATE, CC.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
	M/4 SOLUTION, CC.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
M/4 potassium phosphate		+*	+	+	+	+	−	−	−	−	−	75
		+	+	+	+	−	−	−	−	−	−	70
M/4 potassium chloride		+	+	+	+	+	+	+	+	+	+	75
		+	+	+	+	+	+	+	+	+	+	70
M/4 sodium citrate		+	+	+	+	−	−	−	−	−	−	75
		+	+	+	−	−	−	−	−	−	−	70

* See table 1.

TABLE 3

The effect of salts on the alcohol test

25 CC. MILK PLUS												STRENGTH OF ALCOHOL PER CENT BY VOLUME
	M/4 Mg CHLORIDE, CC.	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	
	M/4 SOLUTION, CC.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
M/4 potassium chloride		+*	+	+	+	+	+	+	+	+	+	75
		+	+	+	+	+	+	+	+	+	+	70
M/4 potassium phosphate		+	+	+	+	+	+	+	−	−	−	75
		+	+	+	+	+	+	−	−	−	−	70
M/4 sodium citrate		+	+	+	+	−	−	−	−	−	−	75
		+	+	+	−	−	−	−	−	−	−	70

* See table.

and sodium citrate, respectively, were added in amounts ranging from 0.1 to 1.0 cc. On applying the alcohol test it was found that the coagulation caused by the 0.5 cc. of M/4 calcium acetate was prevented by 0.5 cc. of M/4 sodium citrate and by 0.6 cc.

of di-potassium phosphate. The potassium chloride did not counteract the effect of the calcium salt.

Table 3 shows the results of the alcohol test on three series similar to those in table 2. Instead of using calcium acetate to cause the milk to become distinctly positive, M/4 magnesium chloride was used in table 3. It was found that the coagulation caused by the 0.5 cc. of M/4 magnesium chloride was prevented by 0.8 cc. of M/4 di-potassium phosphate, and 0.5 cc. of M/4 sodium citrate, respectively. The potassium chloride did not prevent the coagulation caused by the magnesium chloride.

These experiments demonstrate that the salt composition of the milk has a marked effect upon the alcohol coagulation. Small increases in the amount of CaO (0.0112 per cent) and MgO (0.0040 per cent) cause a positive alcohol test. The effect of the calcium and magnesium is counteracted by the citrates and phosphates in the milk, so that a positive test with fresh milk depends upon the relative amounts of these four salts present in it.

The importance of the salt composition of the milk as a factor influencing the alcohol coagulation becomes more apparent when we compare the amounts of the salts that will produce an effect on the coagulation with the amounts of these salts normally present in milk. In the above experiments it was demonstrated that an increase of 0.0112 per cent in the CaO content changed a negative sample to a positive one. Compare this with the normal differences that are found between samples of milk, Sommer and Hart (11) in an analysis of 30 different samples found the CaO content to vary from 0.132 to 0.210 per cent.

FEEDING EXPERIMENT

The effect of the salts on the alcohol coagulation has thus far been demonstrated entirely by their addition to various samples of milk. The additions of salts which were found effective were very small, well within the limits of normal variation of these compounds in milk. In spite of these facts there might be doubt in the minds of some people because these salts were added and were not secreted by the cow as a part of the milk. In order to

overcome this objection a feeding experiment was conducted to determine what effect the feeding of calcium would have on the alcohol test.

Three heavy producing cows in the middle of the lactation period were selected for the experiment. The time of the experiment was divided into four periods. The first or pre-period was an observation period to determine how far from the coagulating point the milk of the animals was, and to note fluctuations and irregularities in the test. During the second period which was from the eighth to the fourteenth day, 50 grams of calcium carbonate was fed to each animal per day. The third period, from the fourteenth to the twenty-second day, the animals were fed 100 grams of calcium carbonate per day. During the fourth period, from the twenty-second to the twenty-eighth day, each animal was fed 200 grams of calcium carbonate per day. The fifth period immediately followed the feeding of the last of the calcium carbonate, up to the time the milk reached the same condition as in the pre-period. The basal ration during the entire experiment consisted of 14 to 16 pounds of grain mixture (500 pounds corn; 200 pounds oats; 200 pounds bran; 100 pounds oil meal); 10 pounds of alfalfa hay and 30 pounds of corn silage. On the evening of the twenty-fourth day the cows refused to eat all of the calcium carbonate. The next day only 100 grams were fed. On the twenty-sixth day 200 grams were again fed and the feeding continued without any changes in amounts.

On the basis of the preceding demonstration that the milk salts are an important factor in the alcohol coagulation, an attempt was made to measure the extent to which a sample was positive or negative. If a sample was negative 5 cc. of milk was taken and M/20 calcium acetate was added in amounts just sufficient to cause a positive test. This amount is indicated in column 3 of table 4. Similarly, if the sample was positive 5 cc. of milk was taken and M/20 potassium phosphate was added in amounts just sufficient to cause a negative test. This amount is recorded in column 4 of table 4. The results are more strikingly pictured in graphs 1, 2 and 3.

TABLE 4

Effect of feeding calcium carbonate on the alcohol test

DATE	Cow: Alice			Cow: Bud			Cow: Doll		
	Alcohol test	m/20 Ca acetate per 5 cc. milk	m/20 K phosphate per 5 cc. milk	Alcohol test	m/20 Ca acetate per 5 cc. milk	m/20 K phosphate per 5 cc. milk	Alcohol test	m/20 Ca acetate per 5 cc. milk	m/20 K phosphate per 5 cc. milk
Pre-period									
		cc.	cc.		cc.	cc.		cc.	cc.
February 15	−	0.2		−	0.2		−	0.2	
February 16	−	0.2		−	0.2		−	0.3	
February 17	−	0.2		−	0.3		−	0.3	
February 18	−	0.2		−	0.3		−	0.1	
February 20	−	0.2		−	0.3		−	0.2	
February 21	−	0.2		−	0.3		−	0.2	
February 23	−	0.2		−	0.25		−	0.2	
February 23	−	0.2		−	0.3		−	0.2	
February 24	−	0.2		−	0.2		−	0.2	
February 24	−	0.2		−	0.4		−	0.2	
50 grams Ca carbonate per day									
February 25	−	0.2		−	0.3		−	0.2	
February 25	−	0.2		−	0.25		−	0.2	
February 26	−	0.2		−	0.2		−	0.2	
February 26	−	0.1		−	0.2		−	0.2	
February 27	+		0.1	−	0.1		−	0.1	
February 27	+		0.15	−	0.05		−	0.05	
February 28	−	0.025		−	0.05		−	0.05	
February 28	+		0.15	−	0.05		−	0.05	
March 1	+		0.15	+		0.1	−	0.05	
March 2	+		0.1	+		0.1	+		0.1
March 2	+		0.1	+		0.1	+		0.1
100 grams Ca carbonate per day									
March 3	+	−	0.1	+		0.1	+		0.1
March 3	+	−	0.1	+		0.1	+		0.1
March 4	+	−	0.1	+		0.1	+		0.1
March 5	+	−	0.3	+		0.25	+		0.2
March 6	+	−	0.3	+		0.2	+		0.3
March 7	+	−	0.4	+		0.3	+		0.4
March 8	+	−	0.3	+		0.3	+		0.3
March 9	+	−	0.4	+		0.3	+		0.5
March 10	+	−	0.4	+		0.2	+		0.5

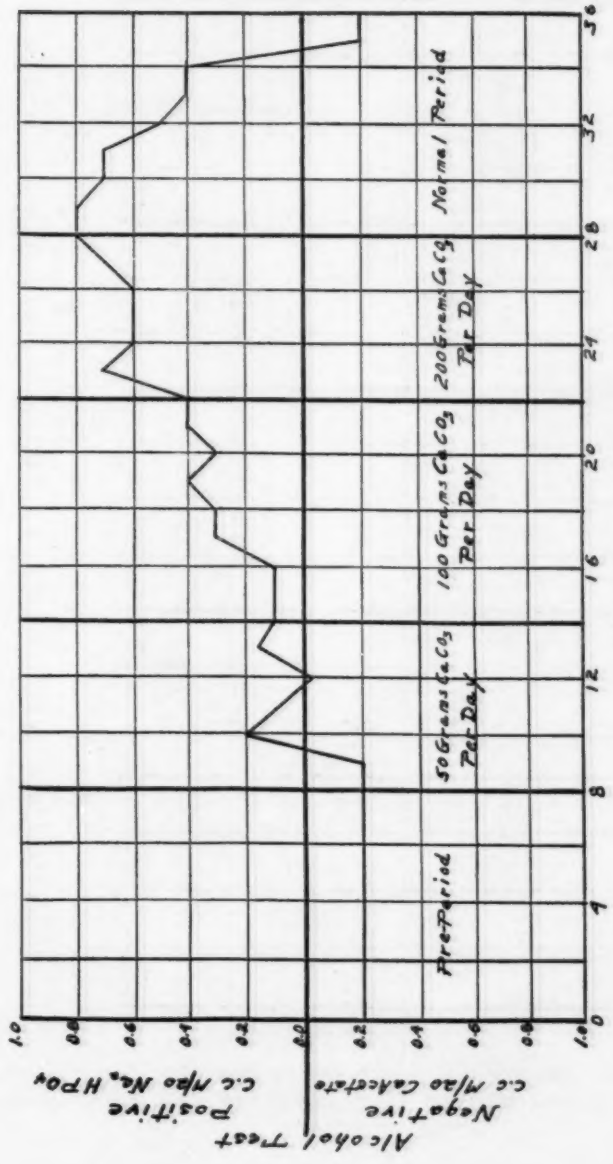
TABLE 4—*Continued*

DATE	COW								
	Alice			Bud			Doll		
	Alcohol test	M/20 Ca acetate per 5 cc. milk	M/20 K phosphate per 5 cc. milk	Alcohol test	M/20 Ca acetate per 5 cc. milk	M/20 K phosphate per 5 cc. milk	Alcohol test	M/20 Ca acetate per 5 cc. milk	M/20 K phosphate per 5 cc. milk
200 grams Ca carbonate per day									
		cc.	cc.		cc.	cc.		cc.	cc.
March 11	+		0.7	+		0.6	+		1.3
March 12	+		0.6	+		0.6	+		0.8
March 13	+		0.6	+		0.6	+		0.7
March 14	+		0.6	+		1.0	+		0.7
March 15	+		0.7	+		?	+		0.8
March 16	+		0.8	+		0.7	+		0.8
Normal period									
March 17	+		0.8	+		0.8	+		0.7
March 18	+		0.7	+		0.8	+		0.7
March 19	+		0.7	+		0.8	+		0.7
March 20	+		0.5	+		?	+		0.6
March 21	+		0.4	+		0.6	+		0.5
March 22	+		0.4	+		0.3	+		0.1
March 23	−	0.2		−	0.3		−	0.1	
March 24	−	0.2		−	0.2		−	0.1	

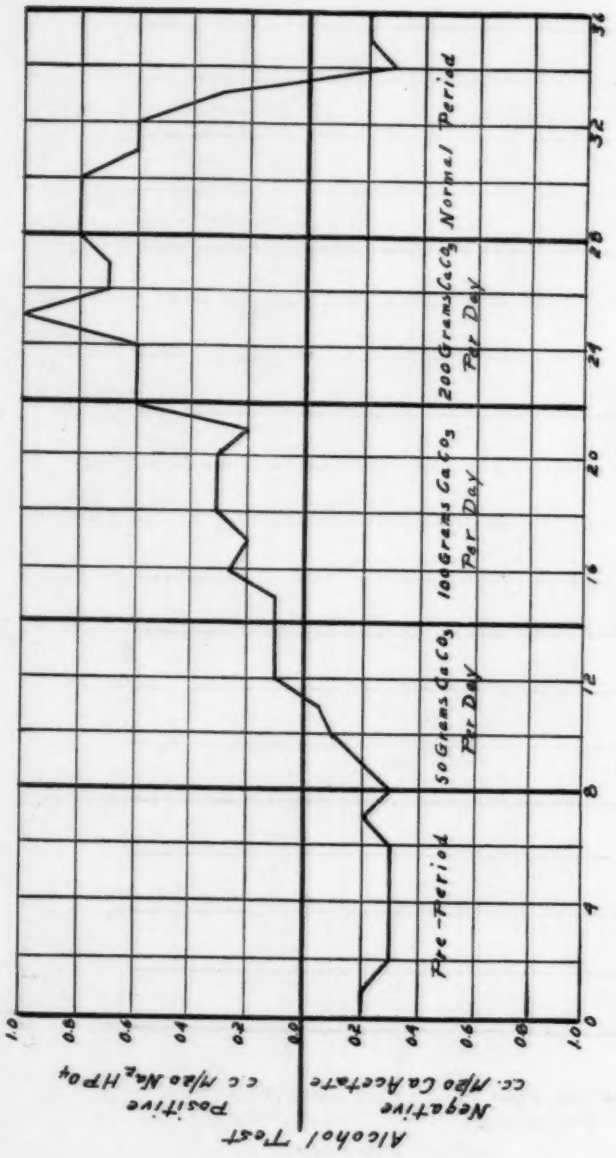
It is not to be inferred that the change in the composition of the milk can be calculated directly from the amount of M/20 calcium acetate and M/20 di-potassium phosphate added in the above manner. This procedure was used merely as a convenient measure of the degree to which the alcohol test was either negative or positive. That there actually was no appreciable increase in the total amount of calcium oxide in the milk as the result of feeding the calcium carbonate is shown in table 5.

RELATIVE IMPORTANCE OF THE EFFECT OF ACIDITY AND OF THE MILK SALTS

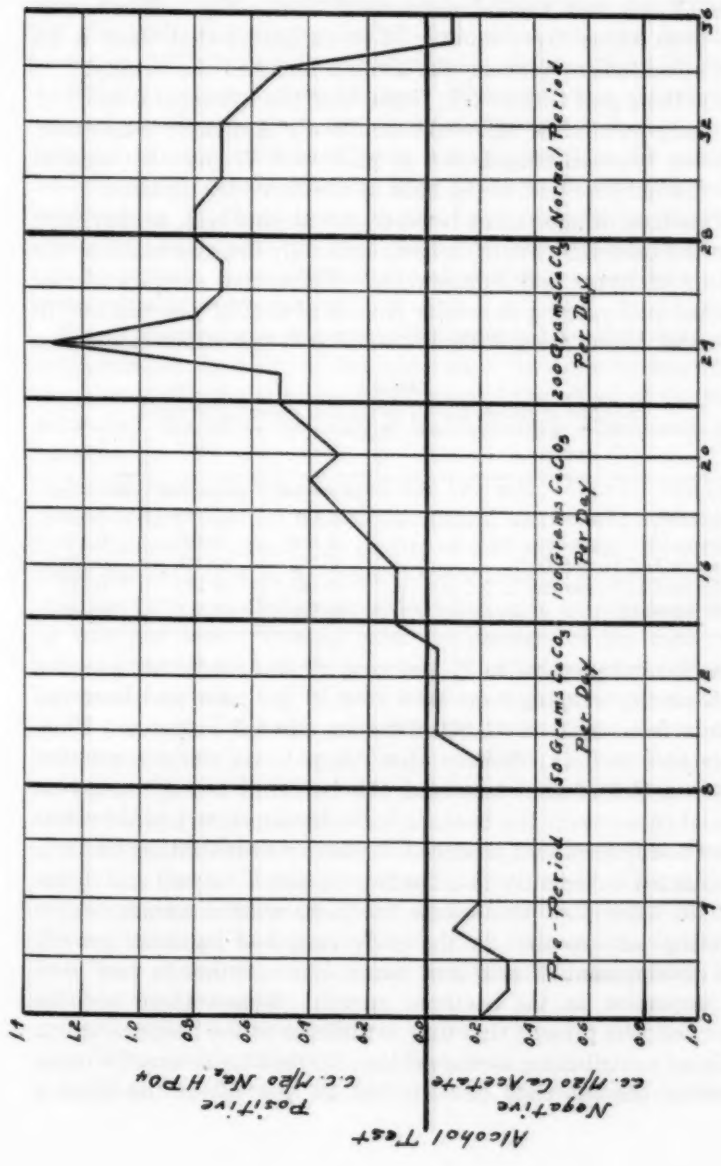
The relation of the acidity to the alcohol test has received much consideration, and the assumption at first was that the



GRAPH 1. THE EFFECT OF $CaCO_3$ IN THE RATION ON THE ALCOHOL TEST OF THE MILK. COW—ALICE



GRAPH 2. THE EFFECT OF $CaCO_3$ IN THE RATION ON THE ALCOHOL TEST OF THE MILK. COW—BUD



GRAPH 3. THE EFFECT OF $CaCO_3$ IN THE RATION ON THE ALCOHOL TEST OF THE MILK. COW—DOLL

alcohol test was a good measure of the acidity. However it has been shown by a number of investigators that there is no strict parallelism between the alcohol text and the acidity.

Dahlberg and Garner (12) found that the results of a study of 211 samples of milk "showed conclusively that there is no direct relation between coagulation of milk with 75 per cent alcohol and the acid content of the milk as measured by titration."

This lack of agreement between the alcohol test, acidity, and also the bacterial counts, is most strikingly demonstrated in the results of Ayers and Johnson (8). Thirty-five samples of raw market milk ranging in acidity from 0.14 to 0.32 per cent and in bacterial count from 2100 to 21,200,000 per cubic centimeter

TABLE 5

The effect of feeding $CaCO_3$ on the CaO content of the milk

PERIOD	ALICE	BUD	DOLL
	per cent CaO	*per cent CaO*	*per cent CaO*
Pre-period	0.187	0.170	0.153
50 grams $CaCO_3$ per day	0.184	0.170	0.157
100 grams $CaCO_3$ per day	0.187	0.174	0.158
200 grams $CaCO_3$ per day	0.186	0.175	0.155
Control period	0.185	0.171	0.154

were alcohol positive to 75 per cent alcohol while 142 samples with acidity ranging from 0.09 to 0.19 per cent and bacterial counts from 2000 to 19,600,000 were alcohol negative. From their results they "believe that there is no definite relation between the alcohol test and the bacterial count, except in special cases where the bacteria have developed to a point where there is sufficient acid produced or where rennet-forming bacteria have acted sufficiently to influence the test." Ayers and Johnson (8) attempted to account for these wide discrepancies by pointing out (*a*) that in the early stages of bacterial growth the development of acid and rennin-like enzymes is very slow in proportion to the bacterial growth, (*b*) that there may be inert bacteria present that may contribute to the bacterial count without contributing to the acidity, (*c*) that there may be other bacteria present that develop but do not affect the alcohol

coagulation. This explanation seems inadequate to account for the wide discrepancy which they observed, the bacterial count in 142 alcohol negative samples ranging from 2000 to 19,000,000 per cubic centimeter. Moreover, this explanation cannot possibly account for their results in which out of 35 samples of raw milk that were alcohol positive, 10 samples had bacterial counts ranging from 2100 to 67,000 per cubic centimeter. In these cases, in the light of their explanation, there certainly could not have been sufficient change produced by the bacteria to cause a positive alcohol test, nevertheless, the tests actually were positive.

These discrepancies can easily be accounted for if we take into consideration the effect of the milk salts. In order to determine experimentally the relative importance of the effect of the milk salts and the effect of acidity the following experiment was conducted:

A sample of milk was divided into two lots. One lot was kept sweet; to the other lot a small amount of starter was added and it was allowed to develop an acidity of 0.42 per cent. By mixing these two lots of milk in proper proportions three series of milk samples were prepared, each series ranging in acidity from 0.12 to 0.38 per cent. Twenty cubic centimeters of the milk was placed in each beaker of three series. The first series was allowed to remain normal; 0.1 cc. M/4 calcium acetate (equivalent to 0.007 per cent CaO) was added to the second, and 0.1 cc. M/4 potassium phosphate (equivalent to 0.0088 per cent P_2O_5) was added to the third. The milk was then tested with the alcohol test and the results tabulated.

As shown in table 6 normal milk became positive to the alcohol test when the acidity had reached 0.26 per cent. The milk to which calcium acetate had been added became positive at 0.20 per cent acidity; and the milk to which potassium phosphate had been added did not become positive until the acidity had reached 0.30 per cent.

The results of this experiment show:

1. That acidity affects the alcohol test.
2. That the effect of the acidity and the salts are additive.

3. That 0.0070 per cent CaO is equivalent to an increase in acidity of 0.06 per cent.

4. That 0.0088 per cent P_2O_5 is equivalent to a decrease in acidity of 0.04 per cent.

From this we can conclude that the effect of the milk salts is of such importance that it can easily account for any lack of correlation between the alcohol test, acidity, and bacterial counts.

TABLE 6

Relative effect of the acidity and of the milk salts on the alcohol test

20 cc. normal milk			20 cc. milk plus 0.1 cc. m/4 Ca acetate			20 cc. milk plus 0.1 cc. m/4 K phosphate		
Acidity	Alcohol test		Acidity	Alcohol test		Acidity	Alcohol test	
	75 per cent	70 per cent		75 per cent	70 per cent		75 per cent	70 per cent
0.12	−*	−	0.12	−	−	0.12	−	−
0.14	−	−	0.14	−	−	0.14	−	−
0.16	−	−	0.16	−	−	0.16	−	−
0.18	−	−	0.18	−	−	0.18	−	−
0.20	−	−	0.20	+	−	0.20	−	−
0.22	−	−	0.22	+	+	0.22	−	−
0.24	−	−	0.24	+	+	0.24	−	−
0.26	+	−	0.26	+	+	0.26	−	−
0.28	+	+	0.28	+	+	0.28	−	−
0.30	+	+	0.30	+	+	0.30	+	−
0.32	+	+	0.32	+	+	0.32	+	+
0.34	+	+	0.34	+	+	0.34	+	+
0.36	+	+	0.36	+	+	0.36	+	+
0.38	+	+	0.38	+	+	0.38	+	+

* See table 1.

INFLUENCE OF THE ACTION OF RENNET

The action of rennet has been studied as one of the factors which influence the alcohol test. Ayers and Johnson (8) tried the effect of prepared rennet and rennet of bacterial origin on the test.

In this work two experiments were also conducted. First, the action of prepared rennet was tried. Rennet was added to six flasks of fresh milk to form dilutions ranging from 1 part of

rennet to 25,000 parts of milk, up to 1 part of rennet to 150,000 parts of milk. For the first fifteen minutes the milk in each flask was tested by the alcohol test at intervals of five minutes. At the end of that period the milk was tested at intervals of fifteen minutes until the milk in each flask became positive.

An examination of table 7 shows that the flask of milk of the lowest dilution was first to show a positive test, the time being thirty minutes. The flask of milk of highest dilution became positive in one hundred and eighty minutes.

It is evident that rennet will produce changes in milk which will cause a positive test. The amount of rennet and the time it is allowed to act are determining factors. The acidity of the

TABLE 7

Influence of prepared rennet on alcohol test

TIME IN MINUTES	0		5		10		15		30		45		60		90		120		180	
Alcohol (per cent by volume)	75	70	75	70	75	70	75	70	75	70	75	70	75	70	75	70	75	70	75	70
Dilution:																				
1:150,000	*−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+
1:125,000	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+
1:100,000	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+
1:75,000	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+
1:50,000	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+
1:25,000	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	+

* See table 1.

milk did not increase sufficiently to affect the test in the short time the experiment was run and therefore can be disregarded.

In order to determine the importance of the rennet forming organisms as a factor influencing the alcohol test, an experiment was conducted in which sterilized milk was inoculated with a culture of a rennet forming organism.

Ayers and Johnson (8) had carried on several similar experiments in which they inoculated sterilized milk with a rennet forming organism and determined the bacterial count at the time the alcohol test became positive. They found that as high a count as 9,000,000 and 15,000,000, per cubic centimeter was required before the milk became positive. As a measure

of the relative importance of rennet forming organisms as a cause for the alcohol test, their experiment is open to criticism; it does not take into consideration the fact that heating the milk removes it farther from the coagulating point.

Auzinger (6) found that milk which gave a positive test at 15°C. sometimes did not give the test after it had been heated for thirty minutes at 60°C. Ayers and Johnson also investigated the effect of heat on the alcohol test and found that milk which had been positive frequently was negative after it had been heated.

No explanation has been offered for this change from positive to negative as the result of heating. This change can now readily be explained on the basis of the effect of the milk salts.

It has been demonstrated by numerous investigators, Soldner (13) Boekhout and De Vries (14), Purvis, Brehaut and McHattie (15), and Grosser (16), that when milk is boiled a precipitation of a portion of the calcium phosphates occurs, the amount of precipitation being proportional in general to the degree and duration of heat applied.

Since small amounts of calcium will cause a positive test, a reduction in the soluble calcium as a result of the heating can readily account for the change from positive to negative. A reduction in the soluble calcium will not only change a positive sample to a negative but will make a negative sample even more negative. Therefore, conclusions drawn on the basis of work with sterilized milk are misleading.

In order to overcome this objection to the use of sterilized milk, an attempt was made to adjust the sterilized milk in such a manner that it was negative to the same degree as the unsterilized milk.

A sample of fresh milk was divided into 200 cc. lots and placed in flasks. Twentieth-molar calcium acetate was added to one flask until it just showed a positive reaction. The remaining flasks of milk were sterilized. To one of the sterilized flasks of milk M/20 calcium acetate was now added until the milk just showed a positive reaction to the alcohol test. Since some of the calcium had been precipitated by the sterilizing process,

this heated milk required more M/20 calcium acetate to make it positive. The difference in the amounts of M/20 calcium acetate necessary to cause a positive reaction in the raw and in the sterilized milk indicated how much calcium to add to bring the milk to the original position relative to the coagulating point. This amount of sterilized M/20 calcium acetate was then added to each of the remaining flasks of milk. Each flask was inoculated with a pure culture of a rennet forming organism

TABLE 8

Influence of rennet of bacterial origin

SAMPLE	AMOUNT OF MILK	M/20 Ca ACETATE ADDED TO FRESH MILK	M/20 Ca ACETATE ADDED TO STERILIZED MILK	DIFFERENCE IN AMOUNT OF Ca ACETATE	ACTERIA COUNTS
	cc.	cc.	cc.		
1	200	3.2	8.8	5.6	700,000 760,000
2	200	3.2	8.8	5.6	500,000 700,000
3	200	3.2	8.8	5.6	980,000 1,000,000
4	200	4.8	8.0	3.2	800,000 690,000
5	200	4.8	8.0	3.2	1,100,000 970,000
6	200	4.8	8.0	3.2	780,000 990,000
Average...	200	4.0	8.4	4.4	855,830

and then incubated at 37°C. The milk was tested at definite intervals, and when the first positive test was obtained, the milk was plated on lactose agar to determine the bacterial count. The results are given in table 8.

An average of six samples shows the bacterial count to be 855,830 per cubic centimeter. These results demonstrate that the rennet forming organisms are of greater importance than the

results of Ayers and Johnson (8) indicated. However, it is only in exceptional cases that the number of rennet forming organisms present in milk approaches even the above figure; so that we must conclude that the rennet forming organisms are a minor factor in the alcohol coagulation.

DISCUSSION

The adherents to the alcohol test claim that it depends upon factors all of which give undesirable characteristics to the milk, such as: (*a*) acidity, (*b*) colostrum milk, (*c*) diseased udders, (*d*) diseased cows, etc. This had generally led to the belief that a positive test invariably indicates that such milk is undesirable

TABLE 9

Summary of factors influencing the alcohol test

FACTOR	EFFECT ON THE QUALITY OF THE MILK	ELIMINATION OF THESE FACTORS BY FARMER
Salt balance	Not undesirable	Cannot be eliminated
Acidity	Undesirable	Can be eliminated
Rennet forming organisms	Undesirable	Can be eliminated
Colostrum	Undesirable	Can be eliminated
Diseased udders	Undesirable	Can be eliminated
Diseased cows	Undesirable	Can be eliminated

and should be discarded. The question arises as to whether or not all milk discarded on the basis of the alcohol test is really undesirable milk. On the basis of the results of this investigation the question would have to be answered in the negative.

Our present knowledge of the alcohol test will warrant the tabulation of factors as shown in table 9. In this table, for the sake of discussion, we may enumerate such factors as colostrum, diseased udders, and diseased cows, although these are not direct factors, but are effective only in so far as they alter the chemical composition of the milk.

In table 9 the salt balance causing a positive alcohol test is listed as "not undesirable." This statement needs modification in the case of milk to be used in the manufacture of evaporated milk. By a comparison of the effect of the salts on the alcohol coagulation as shown by this study, and their effect on the heat

coagulation as found by Sommer and Hart (11) it is seen that both the alcohol and the heat coagulation are produced by an excess of calcium and magnesium over citrates and phosphates. The results of these two independent studies indicate that the alcohol test may be helpful in detecting the milk which causes the troublesome heat coagulation in the sterilization of the evaporated milk. This conclusion is in harmony with the conclusion of Dahlberg and Garner (12) that milk giving a positive alcohol test when concentrated into evaporated milk will coagulate more readily than alcohol negative milk. Therefore from the standpoint of evaporated milk manufacture the salt balance might have to be listed as "undesirable" in table 9. However, since the salt composition of the milk is not under the control of the producer, it is questionable whether a test of this kind would be just to the producer.

Although there are no direct observations available to show to what extent the milk salts are responsible for the positive alcohol test as applied to market milk, we can readily draw a conclusion as to the importance of the milk salts by comparing the normal variations in the milk salts with the amounts found effective in causing a positive test.

Sommer and Hart (11) in an analysis of thirty samples of milk found the CaO content to vary from 0.132 to 0.210 per cent; the MgO content from 0.019 to 0.029 per cent; the P_2O_5 content from 0.193 to 0.294 per cent and the citric acid content from 0.100 to 0.292 per cent. In this investigation it was found that an increase of 0.0112 per cent CaO (table 1), and 0.0040 per cent MgO (table 1) caused a positive test and that an increase of 0.00068 to 0.00884 per cent in P_2O_5 (table 4), changed a positive test to negative.

If we assume that M/20 sodium citrate is equivalent to M/20 potassium phosphate then the amounts of P_2O_5 given above are equivalent to 0.00096 to 0.0038 per cent citric acid. From table 2 it is seen that sodium citrate in equivalent amounts is even more effective than potassium phosphate, so that the figures for citric acid are maximum figures. These figures make it quite apparent that the salt composition undoubedly is the determining factor in many cases.

This is further emphasized by the results given in table 5. The acidity at which the sample of milk was positive varied from 0.20 to 0.30 per cent according to a slight variation in the salt composition.

From table 9 we can readily see that the alcohol test would be desirable because it rejects milk which is positive because of the last five factors mentioned. These five factors give undesirable qualities to the milk and are under the control of the producer, therefore, the alcohol test would be desirable if it detected these factors alone.

However, the alcohol test is also influenced very markedly by the salt composition of the milk; and a salt composition which may cause a positive alcohol test is neither undesirable (except in evaporated milk) nor under the control of the producer. Since this factor is undoubtedly the determining factor in the alcohol test, in many cases, the test must be regarded as ineffective and unjust, except possibly as applied to milk to be manufactured into evaporated milk. A further study of the application of the alcohol test to the manufacture of evaporated milk is in progress in this laboratory.

SUMMARY

1. A slight increase in the magnesium or calcium content will cause a positive alcohol test; an increase of potassium, sodium, chloride, citrate, and phosphate, will not cause a positive alcohol test.

2. The effect of the calcium and magnesium on the alcohol test is counteracted by the citrates and phosphates in the milk. A positive test with fresh milk depends mainly upon the relative amounts of these four salts present in it.

3. A high calcium content in a ration fed to cows can cause coagulation of milk in the alcohol test.

4. The effect of milk salts is of such importance that it can easily account for any lack of correlation between the alcohol test, acidity, and bacterial counts. The effect of acidity and the milk salts are additive.

5. Prepared rennet will cause a positive reaction in the alcohol test. The degree to which a sample of milk becomes positive will depend on the amount of rennet and the time it is allowed to act.

6. The coagulating enzymes produced by rennet forming organisms, numbering 856,000 per cubic centimeter are sufficient to cause a positive alcohol test. However, rennet forming organisms must be regarded as a minor factor in the alcohol test for their prevalence in milk rarely approaches this figure.

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SEASONAL VARIATIONS IN MILK AND FAT PRODUCTION

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In a previous paper (1) the seasonal variations of the percent of fat in cow's milk was presented. The object of this paper is to present the results of a study of the seasonal variations in milk and fat production using the records of the same cows.

The decrease in production due to the advance of the stage of lactation has been shown by Cooke (2), Linfield (3), Woll (4), and Grady (5). Cooke found that cows calving in the fall were more persistent than those calving in the spring. Woll concluded that there was little difference in the rate of decline of the various breeds. Eckles (6), studied the rate of decline of cows freshening every twelve months. Haecker (7) and Gavin (8) made studies to determine the length of time after calving that maximum production was attained.

The favorable influence of spring pasture on milk production has been shown by Cooke (2), Linfield (3), Grady (5), Hills (9), Otis (10), and Humphrey and Woll (11).

The effect on milk and fat production of spring and fall freshening has been shown by McCandlish (12), McDowell (13) and Moore (14). Fall freshening in each case favored increased milk and fat production.

The records of each breed[1] were divided into groups according to the month during which the lactation began, i.e., all cows calving in January were placed together, those in February together, etc. Records made during parts of two lactation

[1] The data for the Guernsey cows were obtained from 3215 Advanced Registry records from eastern and middle western states with a sprinkling from the Pacific Coast states. Values for the Jersey cows were obtained on 305 Register of Merit animals in Missouri. The Holstein data were compiled from 95 Advanced Registry records on animals in the University of Missouri dairy herd.

periods were eliminated. The average monthly milk production for each month was obtained by totaling the production of milk and dividing this total by the number of cows in the group. For the sake of uniformity, all records were then converted to a thirty-day month and the average daily milk production obtained.

As a basis of comparison, the influence of the stage of lactation on the average daily milk production of dairy cattle is presented in table 1.

TABLE 1

Influence of the stage of lactation on the average daily production of dairy cattle

MONTH OF LACTATION	GUERNSEY (3215 LACTATIONS)		JERSEY (305 LACTATIONS)		HOLSTEIN (95 LACTATIONS)	
	Milk daily	Per cent of total	Milk daily	Per cent of total	Milk daily	Per cent of total
	pounds		*pounds*		*pounds*	
1	33.3	10.6	30.0	10.9	39.6	10.4
2	34.3	10.9	29.4	10.6	40.3	10.6
3	32.3	10.3	27.9	10.1	38.9	10.2
4	29.9	9.5	25.9	9.4	36.5	9.6
5	28.1	8.9	24.2	8.8	33.9	8.9
6	26.4	8.4	22.7	8.2	32.5	8.5
7	24.9	7.9	21.4	7.7	30.8	8.1
8	23.7	7.5	20.6	7.5	29.3	7.7
9	22.4	7.1	19.5	7.1	27.9	7.3
10	21.0	6.6	18.6	6.7	25.4	6.7
11	19.5	6.2	17.3	6.2	23.2	6.1
12	17.9	5.7	17.3	6.2	20.1	5.3

An examination of table 1 reveals the fact that the decrease in milk production for the three breeds included, is remarkably uniform. In the case of the Guernsey and Holstein-Friesian breeds the highest average milk production is reached the second month, followed by a very slow gradual decline. The Jerseys, however, reached their maximum the first month and then declined slowly in close agreement with the other breeds. It will be noted that the average daily production the twelfth month is very close to 50 per cent of the production the best month. As compared to the data collected by Eckles (6) it will be seen that

cows on test will hold up their production if forced methods are employed and a 365 day record is desired as compared to cows freshening every twelve months.

By grouping the records according to the month during which the lactation began, the influence of the stage of lactation as a factor influencing milk production can be shown in conjunction with seasonal or other variations.

The data for the Guernsey breed is presented in chart 1. The continuous lines in the charts are the plotted values showing the influence of the stage of lactation on the average daily milk production as shown in table 1 while the columns are the plotted values obtained for the cows grouped according to the month during which the lactation began showing the average production of milk throughout the lactation period. The group of Guernsey cows starting their lactation periods from January to June follow the average figures very closely. The July group decreased in production the second month as compared to the first, probably due to the poor feeding conditions on pasture as well as heat and flies. The low average production of cows calving in August is very noticeable. They run below the average for almost the entire lactation period. The cows calving in the fall from September to December again follow the average fairly closely until the following spring when the production is slightly above the average. This is attributed to the favorable influence of spring pasture. It should be observed, however, that in no case does the milk production actually increase during the spring months. The following explanation is given. Cows on test are generally being forced with an abundance of feed and do not respond to pasture as much as cows receiving only ordinary care, in fact it has been observed that some test cows will actually decrease in milk production when turned on pasture. Another possible explanation may lie in the wide geographical distribution of the cows. The difference in the time when cows were turned to pasture would tend to counter balance each other.

From the standpoint of total milk production, it will be seen that the cows calving in the fall and winter months equal or exceed the average production while those calving during the summer months are below the average.

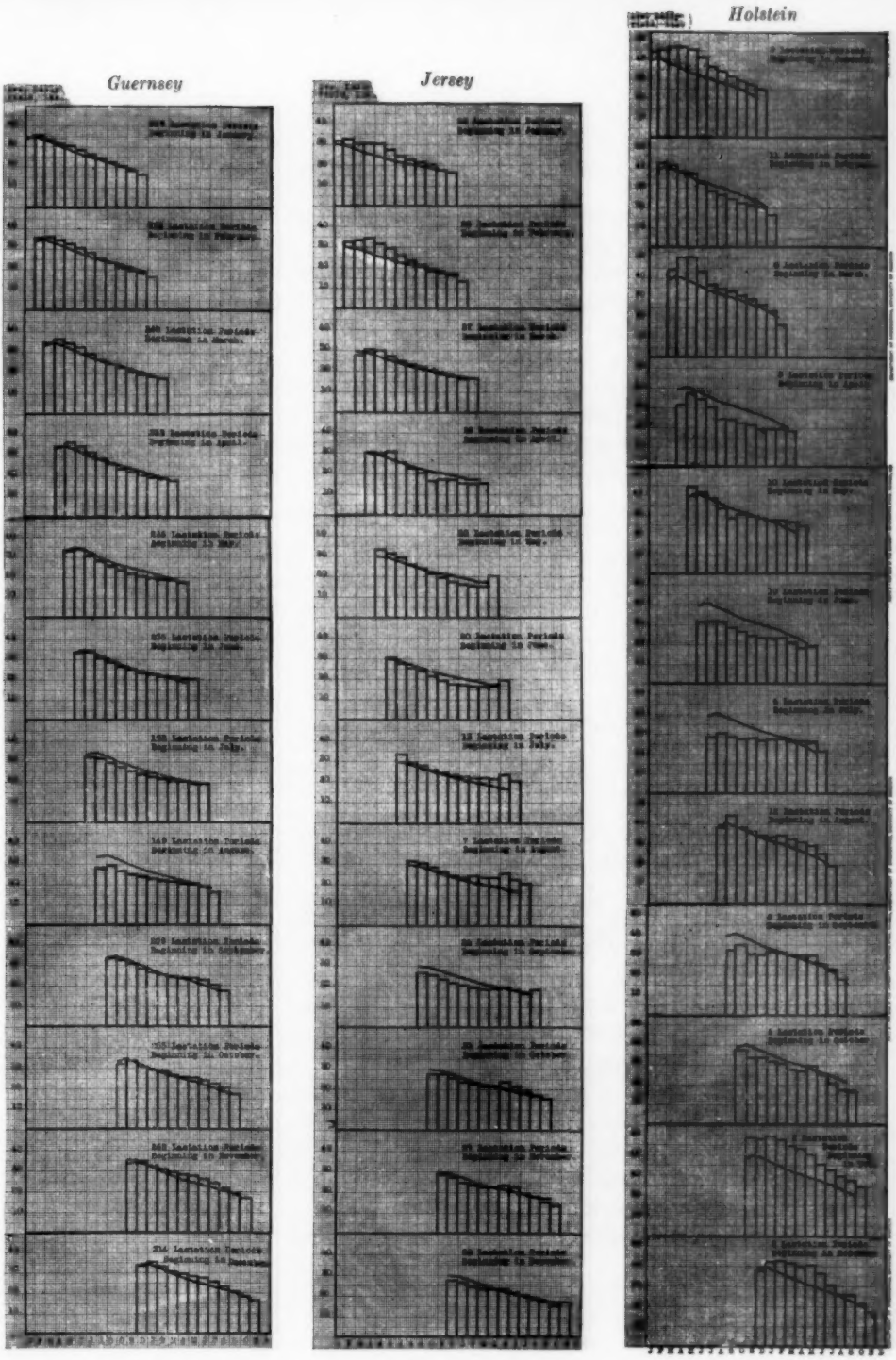

CHART 1 CHART 2 CHART 3

INFLUENCE OF THE SEASON OF THE YEAR ON THE YIELD OF MILK

Continuous lines are the plotted values showing the influence of the stage of lactation on the average daily milk production. The columns are the plotted values showing the influence of the season on the milk yield.

The data for the Jersey breed is presented in chart 2. The groups of cows starting their lactation period in January, February, and March increase in production the second month while those starting during the rest of the year reach their maximum the first month. The favorable effect of pasture is also very noticeable as in practically every case the production of milk increases in May irrespective of the length of the lactation period.

The data for the Holstein-Friesian breed is presented in chart 3. As the number of cows is limited individual variations have not

TABLE 2

Influence of the season of the year on the yearly production of dairy cows

Based on a thirty-day month

MONTH LACTATION STARTED	GUERNSEY YEARLY PRODUCTION		JERSEY YEARLY PRODUCTION		HOLSTEIN-FRIESIAN YEARLY PRODUCTION	
	Milk	Fat	Milk	Fat	Milk	Fat
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
January	9,726	482.8	9,213	480.8	13,683	415.9
February	9,723	485.9	8,913	469.8	10,617	337.8
March	9,642	479.5	8,325	428.9	12,675	398.4
April	9,492	474.2	7,779	418.5	9,039	292.4
May	8,973	462.1	8,121	435.9	12,315	356.5
June	9,384	476.8	7,584	400.4	9,147	279.7
July	9,300	459.0	8,949	445.8	9,828	338.8
August	8,466	429.1	9,126	497.2	11,997	363.6
September	9,414	475.4	7,461	408.5	10,401	322.4
October	9,615	478.2	7,983	417.4	9,924	300.4
November	9,918	494.4	7,884	424.7	14,577	461.4
December	9,645	485.1	7,824	424.8	12,420	373.9

been eliminated. Some significance, however, may be attached to the relatively low production of those cows calving during June and July. The effect of pasture is also shown by the increased milk production during May.

The influence of the season of the year on the yearly production of dairy cows is shown in table 2. With some minor exceptions, the best milk and fat records are made by cows calving during the months from September to April. Probably due to the forced feeding methods employed with cows on official test, there is not as much difference as might be expected.

SUMMARY

Data was presented showing that the average monthly decrease in milk production for all breeds is very uniform, the production during the twelfth month being approximately 50 per cent of the production during the best month.

The principal variations in milk production, aside from that due to the advance of lactation, were found to be largely due to the changes in pasture during the spring and summer months. The fundamental reason for the variation in milk is probably one of nutrition. This in turn being affected to some extent by atmospheric temperature. Cows on test being well fed are probably less affected, either favorably or unfavorably, by pasture than those not being pushed for maximum production.

From the standpoint of total milk production, cows calving in the fall and winter months equal or exceed the average production while those calving during the summer months are generally below the average.

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A STUDY OF THE USE OF SUPERHEATED AND UNSUPERHEATED PLAIN CONDENSED BULK SKIM MILK IN THE MANUFACTURE OF ICE CREAM[1]

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INTRODUCTION

Plain condensed bulk milk is a product made from either whole, partly whole, or skim milk and is used for the most part to supply the necessary solids in the manufacture of ice cream.

Superheated plain condensed bulk skim milk is the unsweetened condensed milk made from completely skimmed whole milk condensed in vacuo at the ratio of about three parts of fluid milk to one part of condensed milk, followed by heating to a temperature from 180° to 190°F. and holding at that temperature for a sufficient length of time to give the body of the condensed milk a heavy consistency. The product is not sterile.

The same definition holds for the unsuperheated condensed skim milk except that the latter is not subjected to a high temperature to thicken it. Like the superheated condensed skim milk, it is not a sterile product.

USE OF CONDENSED MILK IN ICE CREAM MAKING

Condensed milk is used in ice cream making as a source of milk solids not fat. Since a considerable portion of the excess water has been removed, it is possible to combine condensed milk, cream, sugar and gelatin in such proportions that the resulting mixture will have the desired percentages of butter fat, milk solids not fat,

[1] This article is based upon the thesis presented to the Faculty of the Graduate School of the University of Illinois by P. H. Tracy in partial fulfillment of the requirements for the Degree of Master of Science in Dairy Husbandry. The experimental work was completed in June, 1922. A typewritten copy of the original thesis will be found in the files of the Library of the University of Illinois.

The work was done under the supervision of Profs. O. R. Overman and H. A. Ruehe of the Department of Dairy Husbandry, University of Illinois.

sucrose and gelatin. Without the use of a milk product from which a large part of the water had been removed, it would be impossible to obtain an ice cream mix sufficiently high in milk solids not fat to insure a desirable body in the finished product.

In most cases the plain bulk condensed milk used in ice cream making has been superheated. This process consists in heating the condensed milk to a temperature ranging from 180° to 190°F. by the introduction of live steam before the milk is drawn from the vacuum pan, but after it has been evaporated to the desired concentration of solids. Since the superheating causes the condensed milk to thicken, the resulting product is thought to be more desirable for ice cream making, the current belief being that it improves the body of the ice cream. Lack of definite information on that point was the incentive for this investigation.

THE OBJECT OF THE INVESTIGATION

The purpose of this investigation was to make a comparative study of superheated and unsuperheated condensed skim milk with particular reference to their use in ice cream making. An attempt was made to obtain information relative to the following points:

1. The effect of superheating upon the physical state of the milk proteins.
2. The effect of the use of superheated and unsuperheated condensed skim milk upon each of the following:

a. The viscosity of the ice cream mix

b. The finished product: (*1*) Over-run, (*2*) body, (*3*) texture, (*4*) resistance, (*5*) flavor, (*6*) heat resistance.

PLAN OF WORK

The folowing general plan of procedure was used in securing the data.

Preparation and study of the condensed milk[2]

Ordinary separator skimmed milk was used in the manufacture of the condensed milk. The milk was first placed in a large open

[2] Throughout the remainder of this article, the term "condensed milk" will be taken to mean "plain condensed bulk skim milk."

vat, commonly called the forewarmer, having a capacity of 200 to 220 gallons, and heated to about 150°F. by the introduction of live steam. It was then drawn into a 3-foot vacuum pan of the C. E. Rogers type, where the excess water was removed by boiling at a temperature of about 130°F. with about a 24-inch vacuum. Heat was supplied by means of a steam coil jacket and the necessary vacuum was obtained by means of a small steam pump.

After the milk had been concentrated to about 12.5° Baumé at 130°F., 15 or 20 gallons were drawn from the pan to be used for comparative study with the superheated condensed. The remainder was then superheated by forcing in live steam until a temperature of 185° to 190°F. was reached. It was held at that temperature until it had thickened to the desired consistency. The amount of time required for the superheating varied from five to fifteen minutes. The milk was then cooled by maintaining a partial vacuum in the condenser. As soon as the temperature dropped to about 130°F. the milk was drawn into 10-gallon milk cans, and the temperature was further reduced by placing the cans in a large tank and surrounding them with running cold water.

The total solids content of both the superheated and the unsuperheated condensed milk was then determined, and enough water was added to standardize each to 27 per cent total solids.

The relative viscosity of the condensed milk was determined to show the physical effect of superheating upon the body of the condensed milk.

To determine the cause of the difference in viscosity, samples of both the superheated and the unsuperheated condensed milk, after being diluted with about twice their volume of water, were filtered by suction through porous clay filters of the Berkefeld type. The filtrates were then tested for casein and albumin.

The preparation of the mixes

With the exception of the first eight batches (which were half the size of the others) each of the mixes made had a total weight of approximately 50 pounds, which was sufficient to make 8 to 10

gallons of ice cream. Forty per cent cream, skim milk, 27 per cent bulk condensed skim milk, sugar, gelatin, water, and vanilla extract were the only ingredients used. The percentages of fat and solids not fat varied in the different mixes, as shown in the table, but the amount of sugar, flavoring and gelatin used was constant in each batch. The weighing was done on a 10-pound spring scale graduated to ounces.

TABLE 1

Composition of the mixes

BATCH* NUMBER	FAT	M.S.N.F.	SUGAR	GELATIN	T.S.	40 PER CENT CREAM	SKIM MILK	27 PER CENT CONDENSED MILK	WATER	TOTAL WEIGHT†
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*pounds*	*pounds*	*pounds*	*pounds*	
1 and 100	8.07	10.10	11.93	0.5	30.50	10.0	22.9	8.9	2	50.30
2 and 200	8.11	13.92	11.93	0.5	34.37	10.0	11.8	20.0	2	50.30
3 and 300	8.29	17.85	12.10	0.5	38.65	10.0		31.1	2	49.60
4 and 400	10.08	10.04	11.98	0.5	32.51	12.5	19.8	9.3	2	50.10
5 and 500	10.10	13.82	11.93	0.5	36.26	12.5	9.0	20.3	2	50.30
6 and 600	12.03	10.02	11.93	0.5	34.39	15.0	17.0	9.8	2	50.30
7 and 700	12.09	13.82	11.93	0.5	38.25	15.0	5.9	20.9	2	50.30
8 and 800	14.02	9.92	11.93	0.5	36.28	17.5	14.2	10.1	2	50.30
9 and 900	8.10	12.00	11.94	0.5	32.65	10.0	17.0	14.5	2.25	50.25
10 and 1000	10.09	11.96	11.94	0.5	34.41	12.5	14.0	15.0	2.25	50.25
11 and 1100	12.06	11.92	11.94	0.5	36.34	15.0	11.0	15.5	2.25	50.25
12 and 1200	14.05	11.92	11.94	0.5	38.33	17.5	8.0	16.0	2.25	50.25

*Batches 1 through 12 refer to those batches containing superheated condensed milk, while nos. 100 through 1200 refer to the comparable batches containing unsuperheated condensed milk.

†Each of the mixes contained 6 pounds of sugar, 4 ounces of gelatin and 4 ounces of vanilla.

Ordinarily from 8 to 16 different batches were run at one time, half of which were made with superheated and half with unsuperheated condensed milk. With the exception of the condensed milk, the same ingredients were used in all the mixes made at the same time. This, in addition to the fact that the same freezer was used for all and that the temperature of the brine remained fairly constant during one day's freezing, furnished a just basis for a comparative study of the use of superheated and unsuperheated condensed milk in ice cream making.

Table 1 gives the composition and amounts of the different ingredients used in each batch.

Method of determining viscosity

An ordinary 17.6 cc. milk pipette was used in determining the relative viscosity of the ice cream mixes and of the condensed milk. Two different pipettes were used. Due to its extreme visocity, it was necessary to use a pipette with a comparatively large opening to measure the viscosity of the superheated condensed milk. For the unsuperheated condensed milk and the ice cream mixes a pipette with a smaller opening at the discharge end was satisfactory.

In order that all the readings might be reduced to the same basis, the time of discharge of the substance expressed in seconds was in each case divided by the time of discharge of distilled water at the same temperature. The result was termed the relative viscosity.

The liquid to be measured was first tempered to 20°C. It was then drawn into the pipette, which was marked at the top and bottom of the enlarged portion. The time required for the top of the column to pass from the upper to the lower of these graduations was then determined with a stop watch. While it was emptying, the pipette was held in a vertical position in a ring stand. It was thoroughly cleaned and dried between operations by means of hot water, alcohol and ether. The temperature of the room was kept as near 20°C. as possible.

Since it was found that duplicate runs resulted in very close checks, single runs were used for mixes 1 through 8 in order to facilitate matters, as it was desirable to measure the viscosity the same day the batches were frozen. However, two runs were made on batches 9 through 12 and the averages of these were used in determining viscosity.

Method of freezing

The mixes were ususally aged for twenty-four hours before being frozen. An attempt was made to have the temperature of the mix not higher than 45°F. at the time it was placed in the

freezer. A chain-driven 50-quart horizontal brine freezer was used to freeze the ice cream. In freezing batches 9 through 12 and 900 through 1200, the ice cream was allowed to whip until the maximum amount of air, as determined by the Mojonnier over-run tester, had been obtained. Batches 1 through 8 and 100 through 800 were drawn when the appearance of the ice cream warranted it. Both methods are used in commercial plants.

The freezer was thoroughly rinsed with water after each batch was drawn in order that the composition of the following mix might not be altered in any way.

Method of determining the over-run

The over-run on batches 1 through 8 and 100 through 800 was determined in the following manner. A one-half pint Seal-Right paper carton was weighed and then filled with the unfrozen mix and weighed again. It was next filled with the frozen ice cream, which in turn was weighed. The percentage of air that had been incorporated in the ice cream, or the over-run, was then determined by subtracting the net weight of the ice cream from the net weight of the mix, dividing the difference by the net weight of the ice cream and multiplying by 100.

The over-run on batches 9 through 12 and 900 through 1200 was obtained with the Mojonnier over-run tester.

Taking the samples

In order that the quality of the finished product might be determined, three samples were taken from each batch in small one-third pint cartons. These samples were always taken from the top of the first can drawn, which gave a fair representation of the whole batch. The samples were placed in a hardening room, which was kept at a temperature ranging from 11°F. to −4°F.

Judging the ice cream

The ice cream was removed from the hardening room at about seven day intervals and judged by Profs. H. A. Ruehe, O. R. Overman, and A. S. Ambrose of the Department of Dairy

Husbandry, together with the author. The criticisms on each batch were the summarized conclusion of this group of judges and were altogether of a comparative nature, as no attempt was made to use the score card.

Method of determining heat resistance

The difference in the ability of ice cream, differing only in the use of superheated and unsuperheated condensed milk, to withstand the influence of heat was determined by subjecting samples of comparative batches of ice cream to the same heat conditions and measuring the amount that melted and dropped off in a given time. Each batch was represented by triplicate samples.

For this purpose one-half pint and pint paper cartons were used. Since the amount of air incorporated might have some effect upon the rate of melting of the ice cream, samples having the same overrun (as determined by the Mojonnier over-run tester) were used in each comparison.

EXPERIMENTAL RESULTS

Effect of superheating upon the milk protein

The effect of superheating upon the relative viscosity of the condensed milk is shown by the following table. In the second column is given the viscosity of the condensed milk before it was superheated, while in the third column is given the viscosity of the same condensed milk after it had been superheated. In all cases the total solids content was standardized to 27 per cent.

SAMPLE NUMBER	BEFORE SUPERHEATING	AFTER SUPERHEATING
1	4.2	93.7
2	2.8	14.2
3	3.4	176.1
4	3.2	241.4
5	2.0	114.0
6	1.7	85.0
7	1.8	95.5
8	2.5	491.8

The extremely viscous condition of the condensed milk that exists after the superheating process has been completed is commonly referred to as the "liver," or coagulum. In a way these terms suggest a possible explanation of what happens when condensed milk is superheated, but a more definite explanation is lacking.

From a study of the properties of the butterfat, milk sugar and ash content of milk, it is thought that heating these substances to a temperature of 190°F. would not be responsible for the increased viscosity of the condensed milk. If this is true, it necessarily follows that the increased viscosity of the condensed milk brought about by superheating is due to a change in the physical form of the milk proteins. This was proven by filtering both superheated and unsuperheated condensed milk through porous clay filters and analyzing the filtrate for both casein and albumin.

The milk was first thoroughly mixed with twice its volume of water and then placed in porous clay filters of the Berkefeld type. A colorless filtrate was secured by applying suction to the clay plate.

In case of the superheated condensed milk this filtrate contained no protein. The filtrate of the unsuperheated condensed milk, however, gave very pronounced reactions with the protein tests used. The following tests for protein were used:

1. Xanthoproteic reaction
2. Millon's reaction
3. Biuret reaction

The filtrate from the unsuperheated condensed milk was further analyzed for casein and albumin. About 50 cc. of the filtrate was first made neutral with dilute sodium hydroxide. Dilute hydrochloric acid was then added a few drops at a time until 1.5 cc. had been added. The filtrate was allowed to stand a few minutes, but no precipitate was formed, indicating the absence of casein. Another portion of the filtrate was then boiled until a floculent precipitate was obtained, indicating the presence of albumin.

The high degree of viscosity that occurs in superheated con-

densed milk may be explained by the fact that the superheating changes the ablumin from a colloidal to a finely divided precipitated form. In this state it is possible that the albumin particles adsorb not only each other but the casein as well, producing an effect not unlike an emulsion, the albumin in this case being the dispersed phase.

The effect of the use of superheated and unsuperheated condensed milk upon the ice cream

To determine the effect of the use of superheated condensed milk upon the ice cream, comparative criticisms were made of the various lots of ice cream containing superheated condensed milk with those containing unsuperheated condensed milk. Twelve different combinations of fat and milk solids not fat were represented. Each of the 80 different batches were judged three times, making in all 240 criticisms.

The data obtained show conclusively that the use of superheated condensed milk causes the ice cream to have a better body and a smoother texture and also increases the amount of resistance. On the other hand, ice cream containing unsuperheated condensed milk is not so likely to develop an old or condensed milk taste upon being held in storage and has a superior flavor even when fresh, due to the fact that the fresh milk flavor of the unsuperheated condensed milk has not been destroyed by heating to a high temperature.

Since superheating causes a change in the physical state of the milk proteins, it might be expected that the use of superheated condensed milk would be a contributory factor to the development of sandiness in the ice cream. However, the data indicate that there is no appreciable difference in the tendency which comparable batches have to become sandy.

Since the greatest amount of condensed milk was used in those batches having the highest percentage of milk solids not fat, it might be expected that those batches would show the greatest effect of the use of superheated condensed milk. However, the converse was true, for the greatest difference was in those batches containing a low percentage of milk solids not fat and in which

only 9 or 10 pounds of condensed milk were used. This can be explained by the fact that the addition of a slight amount of solids is more noticeable up to a certain point than it is beyond that point. Consequently, the addition of a few more solid particles to those mixes containing from 30 to 33 per cent total solids would seem to have a greater effect upon the texture, resistance and body of the ice cream than the addition of two or three times as many particles to those mixes containing from 35 to 38 per cent total solids.

The data also show that it is possible for the use of unsuperheated condensed milk to result in a better ice cream than that made with superheated condensed milk. Referring to batches 3 and 5, due to the high solids content, neither the body, texture, nor resistance of the ice cream was as desirable as that of the comparable batches containing unsuperheated condensed milk. By way of explanation, it may be said that the percentage of total solids in these batches was probably such that the addition of any more solid particles subtracted from, rather than added to, the merits of the ice cream.

It was the opinion of the judges that in general the use of the superheated condensed milk was equivalent to the addition of about 2 per cent solids. For example, it was noted that batch 1200, containing unsuperheated condensed milk and having 38.33 per cent total solids, was comparable to batch 11, which contained superheated condensed milk and had a 36.34 per cent total solids content. Also, batch 1100 (containing unsuperheated condensed milk) seemed to have about the same texture and resistance as batch 10 (containing superheated condensed milk), which contained 2 per cent less total solids.

Effect of the use of superheated condensed milk upon the viscosity of the ice cream mix

Since superheating results in a marked increase in the viscosity of the condensed milk, it is to be expected that an ice cream mix containing superheated condensed milk will have a greater viscosity than that in which concentrated skim milk is used.

This difference is shown in the following graphs of the average viscosity of three series each of batches 1 through 12, and 100 through 1200.

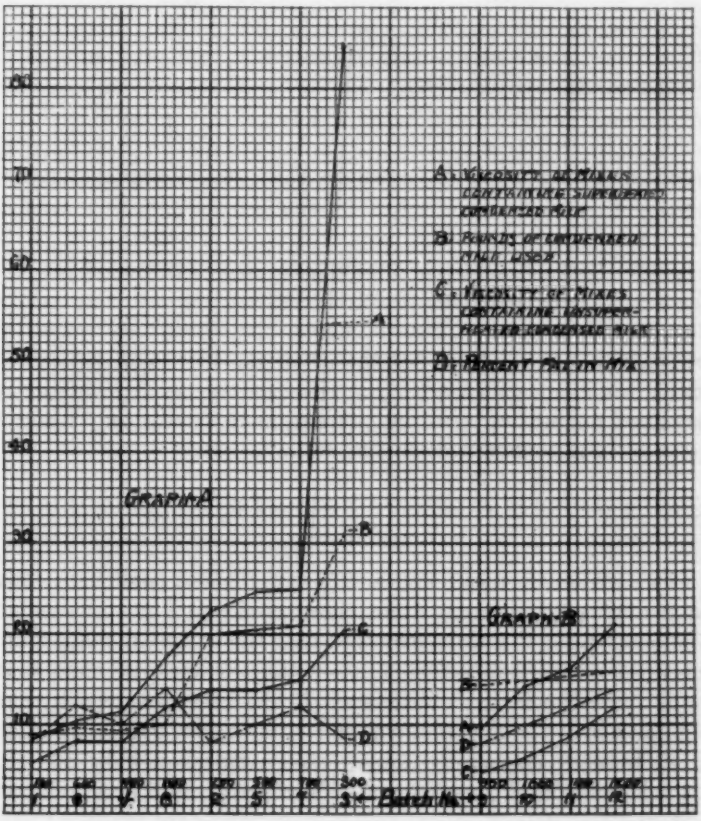


FIG. 1. GRAPHS SHOWING THE EFFECT UPON THE VISCOSITY OF THE MIX OF THE USE OF SUPERHEATED CONDENSED MILK, AS WELL AS THE RELATION BETWEEN VISCOSITY, THE AMOUNT OF CONDENSED MILK USED AND THE PER CENT OF BUTTERFAT IN THE MIX

The graphs in figure 1, in addition to showing the difference in the average viscosities of the batches also show the relation between the viscosity, the amount of condensed milk used, and the percentage of butterfat in the mix.

Graph A plainly shows the increase in viscosity due to the use of superheated condensed milk and indicates that as the amount of condensed milk used was increased the viscosity of the mix also increased, the amount of increase being modified somewhat by the percentage of butterfat. However, the greater increase was due to the percentage of milk solids not fat and the amount of condensed milk used. This is shown by the increase in viscosity of batches 5 and 500 and batches 3 and 300 over batches 8 and 800 and 7 and 700 respectively. In both cases the percentage of milk solids was the same; however, those containing the greater percentage of milk solids not fat (which also contained the greater amount of condensed milk) had the greater viscosity.

Graph B also shows how the increase in percentage of fat and the amount of condensed milk used causes an increase in the viscosity of the mix. Since the percentage of milk solids not fat was constant, while the percentage of fat increased with each batch, the increase in viscosity in this case was mostly due to the increased amount of butterfat present, as there was only a slight increase in the amount of condensed milk used.

Effect of the use of superheated condensed milk upon the over-run obtained

Since ice cream mixes containing superheated condensed milk have a greater viscosity than those containing unsuperheated condensed milk, it is to be expected that the ice cream made from the former will have a higher percentage of over-run than that made from the latter. That such is the case is shown by the comparison of the average over-run obtained on two series each of 12 batches containing superheated condensed milk and 12 batches containing unsuperheated condensed milk, as given in table 2.

The ice cream represented in Part I of table 2 was drawn from the freezer when it appeared to have been frozen sufficiently. This is the method commonly used in commercial practice. There are plants, however, where the ice cream is not drawn until a maximum over-run is obtained. This was the method followed in securing the data given in Part II.

It will be noted that in practically all cases a greater over-run was obtained from those mixes containing superheated condensed milk than from those containing unsuperheated condensed milk.

Effect of the use of superheated condensed milk upon the heat resistance of the ice cream

The relation existing between the heat resistance of ice cream containing superheated condensed milk and that containing unsuperheated condensed milk is shown in table 3.

TABLE 2

Effect of the use of superheated condensed milk upon the over-run obtained

BATCH NUMBER (SUPERHEATED)	OVER-RUN	BATCH NUMBER (UNSUPERHEATED)	OVER-RUN
Part I			
1	85.7	100	73.4
2	86.3	200	90.5
3	83.0	300	70.0
4	83.8	400	74.9
5	73.5	500	58.5
6	84.2	600	68.4
7	80.6	700	67.8
8	78.0	800	56.9
Part II			
9	78.7	900	72.3
10	81.0	1000	74.7
11	81.7	1100	71.7
12	84.3	1200	74.3

It is evident from these data that ice cream containing superheated condensed milk will stand up much better when subjected to a temperature above freezing than will that in which unsuperheated condensed milk is used, the amount of difference depending upon the quantity of condensed milk used.

The difference in the way in which comparative batches of ice cream melted is also shown in the following pictures taken of samples 16a, 17a and 18a recorded in table 3. Picture 1 represents the appearance of the samples at the start of the experiment.

Picture 2, taken of the samples at the end of one hour, clearly shows how the increase in the amount of superheated condensed milk used increases the ability of the ice cream to stand up. The

TABLE 3

Difference in melting of ice cream made from superheated and unsuperheated condensed milk

NUMBER	WEIGHT			MELTED		TEMPERATURE	OVER-RUN
	At start	After one hour	After two hours	After one hour	After two hours		
	grams	*grams*	*grams*	*per cent*	*per cent*	*°C.*	*per cent*
*16 a	250	237	125	5.2	50.0	20.5	70
*16 b	253	238	133	5.9	47.8	20.5	70
*16 c	249	235	121	5.6	59.4	20.5	70
Average	250.7	236.7	126.3	5.6	49.7		
†17 a	246	236	144	4.1	41.7	20.5	70
†17 b	240	231	138	3.8	42.5	20.5	70
†17 c	238	230	129	3.4	45.8	20.5	70
Average	241.3	232.3	137	3.7	43.3		
†18 a	235	235	159.5	0	32.1	20.5	70
†18 b	242	242	168	0	30.6	20.5	70
†18 c	238	238	173	0	27.3	20.5	70
Average	238.3	238.3	166.8	0	30.0		

Composition of mixes in table 3

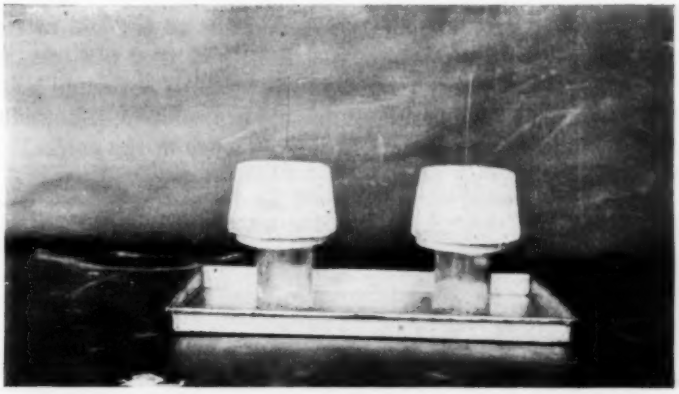
NUMBER	FAT	M.S.N.F.	SUGAR	GELATIN	T.S.	40 PER CENT CREAM	SKIM	CONDENSED	WATER
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*pounds*	*pounds*	*pounds*	*pounds*
*16: a, b, c	10	10	12	0.5	32.5	12.5	19.8	9.3	2.00
†17: a, b, c	10	10	12	0.5	32.5	12.5	19.8	9.3	2.00
†18: a, b, c	10	10	12	0.5	32.5	12.5		15.9	15.35

* Unsuperheated condensed milk was used.

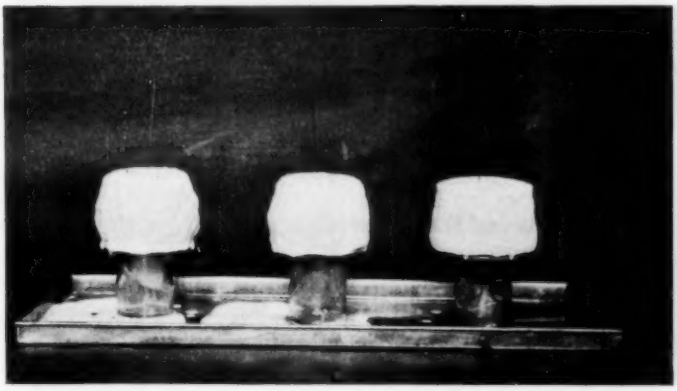
† Superheated condensed milk was used.

composition of all three batches was the same, the only difference being the condensed milk used. In the sample on the left 9.3 pounds of unsuperheated condensed milk were used; in the middle sample 9.3 pounds of superheated condensed milk were used; while

in the third sample 15.9 pounds of superheated condensed milk were used. The difference in the percentage melted from the first



PICTURE 1. APPEARANCE OF ALL THE SAMPLES BEFORE EXPOSURE TO ROOM TEMPERATURE

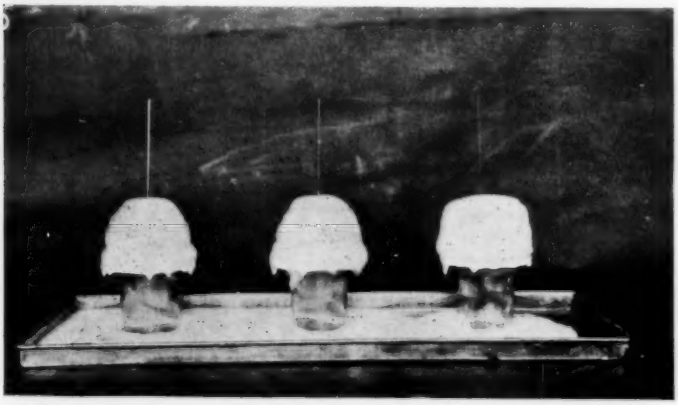


PICTURE 2. APPEARANCE OF THE SAMPLES AFTER ONE HOUR'S EXPOSURE TO ROOM TEMPERATURE

two samples is hardly noticeable, being 1.1 per cent. However, the difference between either the first or second and the third is

more striking. The percentage melted in the first case was 5.2; in the second, 4.1; whereas only three drops had fallen from the third sample when the picture was taken.

Picture 3 shows samples 16a, 17a and 18a at the end of two hours. The appearance of samples 16a (left) and 17a (center) is about the same, the difference in the percentage melted being 8.3. When sample 16a and 18a (right) are compared, however, a greater difference can be seen, the difference in the percentage melted being 17.9.



PICTURE 3. APPEARANCE OF THE SAMPLES AFTER TWO HOURS' EXPOSURE TO ROOM TEMPERATURE

Both the data and the pictures show rather conclusively that the use of superheated condensed milk causes the ice cream to have more resistance to temperatures above the freezing point, the ice cream having the greatest resistance being that containing the largest amount of the superheated condensed milk.

CONCLUSIONS

1. Superheating condensed skim milk causes the albumin to be changed from a colloidal to a precipitated form.

2. The use of superheated condensed milk increases the viscosity of the ice cream mix.

3. The use of superheated condensed milk improves the texture and body of the ice cream and increases its resistance.

4. Ice cream containing unsuperheated condensed milk has a better flavor than that containing an equal amount of superheated condensed milk.

5. A larger over-run can be obtained from a mix containing superheated condensed milk than from a mix containing an equal amount of unsuperheated condensed milk.

6. An ice cream containing superheated condensed milk will have a greater heat resistance than that containing an equal amount of unsuperheated condensed milk.

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THE NUTRITIVE VALUE OF THE PROTEINS OF COCONUT MEAL, SOY BEANS, RICE BRAN AND CORN

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Undoubtedly the most systematic and scientific method of formulating the food requirements of farm animals is that of the late Dr. H. P. Armsby. The Armsby standards for the maintenance of farm animals, for their growth and fattening, and for the maintenance of milk production, are not in the main empirical, as are so many others, but are the result of a searching analysis of physiological functioning. While the experimental data upon which they are based are not always so complete as to make them in any sense final; while the interpretation of the data may not in all cases be above criticism; and while some of the standards are not as widely applicable as they are stated to be; nevertheless, the general method by which they are deduced and the terms in which they are expressed are so far superior to other methods and other terms as to put them in a class by themselves. The conception of "net energy" and the direct and indirect determinations of the net energy values of a large number of feeds of common use in this country, permits a wide application of the Armsby standards in American feeding practice, insofar as any feeding standard may be so applied to advantage.

In determining the energy requirements of animals for maintenance, the method of Armsby has been simply to determine experimentally the energy expenditure of the fasting, resting animal, at moderate external temperatures. An amount of net energy equal to this expenditure should maintain the animal. In determining the energy requirements for production, the actual energy content of the added tissue or of the milk secreted represents the net energy required, recognizing that the net energy value of feeds may vary with the type of production.

Unfortunately the determination of protein requirements is not so simple. While it seems to be a fact that the loss of nitrogen sustained by an animal on a ration containing sufficient energy but free from protein and other forms of nitrogen, is a measure of the protein minimum for the maintenance of life, it cannot be concluded that an equivalent amount of digestible protein will cover this requirement. Nor can it be said that the protein content of added tissue or the protein content of milk secreted measures directly the amount of digestible protein required for their elaboration. The reason is that there is a wastage of digestible protein in serving body purposes just as there is a wastage of digestible energy. While the latter wastage seems to be a physiological phenomenon, the former seems to be largely a chemical phenomenon, due to the difference in chemical structure between body proteins and food proteins. One seems to be as inevitable as the other, however.

Therefore, before a determination of the amount of food protein required for a certain purpose can be made, it is necessary to know not only the amount of protein the body needs, but also the inevitable wastage of food protein in covering this need. As is well known this wastage of protein differs rather widely among different forms of food protein, and any measure of the nutritive value of the protein of a given food must include not only the wastage due to incomplete digestibility, but also the wastage of digestible material representing the fragments of food protein (amino acids) left over in its conversion into body protein, or in its utilization in the "repair" of the body tissues. These left-over fragments, though available for the production of energy or even for the storing of energy, cannot be used for the covering of protein needs for the lack of proper supplementary fragments.

The simplest and the most serviceable method of measuring the nutritive value of digestible protein seems to be that of Karl Thomas[1]. The value of a protein according to this method (its so-called "biological value") is measured by the

[1] Thomas, Karl, Arch. Anat. und Physiol., Physiol. Abt., 1919, 219.

number of parts of body protein that may be spared by 100 parts of the digestible food protein in question. Thus, a value of 60 would mean that 1 pound of the digestible food protein would be required to cover a loss of 0.6 pound of body protein in the endogenous protein catabolism. In other words, if an animal loses 0.6 pound protein per day (urinary N $\times$ 6) on a protein-free ration containing sufficient energy, 1 pound of the digestible protein in question would be required daily for maintenance.

It seems probable that the same conception can be extended to cover the other functions of protein in the body besides that of replacing nitrogen degraded in the so-called "wear and tear" processes of metabolism, whatever these may be. For example, when the protein intake is sufficiently high to support growth, it may be found that 1 pound of the digestible protein in question may be required to form 0.7 pound of tissue protein. Hence, a coefficient of 70, entirely analogous to Thomas' "biological value" for maintenance, may be given to this protein. If the values of proteins for maintenance and for growth are not greatly different, the coefficient assigned to a protein may include all the structural purposes for which protein is used in the body, so that of every pound of digestible protein consumed, a more or less constant amount can be used for maintenance and growth. After considerable experimentation we have adopted this method of expressing the value of digestible protein in nutrition.[2]

By the use of these values of Thomas it would be possible to formulate protein requirements by the same method Armsby

[2] While it is probably true that all proteins have lower biological values for growth than for maintenance, our experience has shown that the level at which the protein is fed is probably of greater importance in most cases in determining its value to the body in satisfying nitrogen requirements than the purposes for which it is used in the body. In covering the maintenance requirement the biological value of a protein seems to be lower when fed at a 10 per cent level than when fed at a 5 per cent level, so that at the former level the difference in the values of the protein for maintenance and for growth is probably not great. While our experience with rations containing more than 10 per cent of protein is limited, such as it is it indicates that no marked further decrease in biological value need be expected until the level is so high that maximum growth is possible.

has used in formulating energy requirements, and to list the "net protein" value of feeds in the same way as their net energy values have been listed.

Few reliable determinations of the nutritive value of the protein of foods by the method of Thomas have been published to date. Nevens, working in this laboratory and using a method developed here after several years of work, has recently published[3] the results of some metabolism studies on rats designed to measure the value for maintenance and growth of the proteins of corn, alfalfa hay, and cottonseed meal, alone and combined in various ways. The work to be reported in this paper, extends this investigation to coconut meal, soy beans, and rice bran, and includes studies of combinations of these feeds with each other and with corn. Rats were the experimental subjects; and the technique of the collection of urine and feces was identical with that used and fully described by Nevens, as was also the method of calculating the nutritive value of the proteins.

THE LOSSES OF NITROGEN ON AN N-FREE RATION

The nitrogen loss from the body due to the constant disintegration of tissue in the course of the endogenous catabolism was determined by feeding the rats a nitrogen-free but otherwise adequate ration for ten days, and by measuring the losses of nitrogen in the urine for the last seven days of this period. The losses of nitrogen in the feces per gram of this ration consumed was taken as a measure of the so-called "metabolic nitrogen" of the feces, and was used in subsequent periods in the determination of the actual digestible nitrogen of the protein rations fed.

Such a nitrogen-free feeding period constituted the first and the last (the eighth) balance periods of the experiment. The data obtained are included in table 1.

For the first period on this ration the urinary nitrogen per day per 100 grams of body weight averaged 20.6 mgm. with only small variations among individual rats with the exception of rat 131. We take these values as measures of the endogenous

[3] Nevens, W. B., J. Dairy Science, 1921, vi, 552.

nitrogen excretions of the rats, representing losses that must be made good by dietary protein if the body weight is to be maintained. The daily fecal nitrogen on the nitrogen-free diet obviously has its origin in the body of the rat, and may be taken to represent the wastage of body nitrogen in digestion. It would

TABLE 1

Metabolism of rats on a nitrogen-free ration

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	AVERAGE FEED CONSUMED DAILY	DAILY URINARY NITROGEN	DAILY FECAL NITROGEN	DAILY URINARY N PER 100 GRAMS LIVE WEIGHT	FECAL N PER 100 GRAMS FEED
		grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*
131	1	73.0	66.5	5.43	19.4	8.2	27.9	150
132	1	46.0	43.0	3.72	8.7		19.6	
133	1	62.0	57.0	5.24	11.4	9.0	19.2	173
134	1	74.0	66.5	5.27	16.1	5.6	22.9	106
135	1	57.0	52.0	5.29	8.8	11.9	16.2	225
136a	1	82.0	75.0	5.16	16.1	14.6	20.5	283
137	1	45.0	41.5	3.67	7.5	6.0	17.4	165
138	1	67.0	59.5	5.32	12.8	11.3	20.3	213
139	1	54.5	46.5	4.23	11.0	9.7	21.7	229
Average							20.6	193
131	8	99.0	87.0	3.56	22.6	9.3	24.3	261
132	8	64.0	58.5	2.64	11.8	5.2	19.4	197
133	8	84.5	77.5	3.29	18.3	6.3	22.6	191
134	8	139.0	130.0	6.09	17.5	8.8	13.0	144
135	8	118.5	108.0	5.67	12.3	9.4	10.9	167
136b	8	154.0	140.0	4.39	20.3	12.1	13.8	276
137	8	88.5	77.5	2.66	16.7	5.3	(20.1)*	198
138	8	125.0	112.0	4.25	16.8	8.0	14.2	190
139	8	81.0	72.0	3.64	12.9	8.2	16.8	227
Average							16.9	206

* This value is not used here in computing the average, nor in future computations, because of the low food intake in proportion to the size of rat.

seem to be related to the amount of food consumed and averaged 193 mgm. per 100 grams of food. Considerable individual variations appear in this value, which seems to be affected by factors not under control in our experiments, such as the consumption of filter paper, with which the bottoms of the metabolism dishes were covered.

In the eighth experimental period, the rats were again put upon the nitrogen-free ration and collections of urine and feces were made daily after a three-day preliminary period, and composited for one week. In this period the loss of nitrogen in the urine per day per 100 grams of rat was, in all cases but one, less than the losses for corresponding rats in the first period, and sometimes very much less. It has been our experience that rats kept for several weeks confined in our metabolism dishes, show decreasing rates of endogenous loss of nitrogen. It seems probable that this indicates a diminished vitality of the experimental animals, just as a decreasing basal metabolism of energy has of late been found to be associated with decreasing vitality. Therefore, in the periods intervening between the two metabolism trials just described, it has been assumed that the endogenous losses of the rats decrease, in proportion to their weight, in a linear fashion from the value obtained in period 1 to the value obtained in period 8.

The fecal nitrogen excreted per 100 grams of food consumed in period 8 varied somewhat among the different rats from the corresponding values in period 1. In only two or three cases, however, is the difference so great that the average of the two values for any rat cannot be used in computing digestible nitrogen in the intervening periods. For these three cases, i.e., rats 131, 134, and 135, it was again assumed that the change from the value in period 1 to the value in period 8 was linear. The average value for the period was 206 mgm. of fecal nitrogen per 100 grams of food consumed.

RESULTS WITH LOW PROTEIN RATIONS

The rations containing the feeds to be tested were made up so as to contain 5 or 10 per cent of protein and to be adequate in all known respects except for the quality of the protein. In table 2 will be found the recipes for the rations and their nitrogen contents as determined by Kjeldahl analysis.

Rations 1, 2, and 3 contain the proteins of coconut meal, soybean, and corn at a 5 per cent level. Such rations will support very little if any growth, and the experimental results

obtained with them may logically be considered by themselves. These results are contained in table 3. A three-day preliminary period always followed a change of ration, and all collection periods were of seven days' duration.

The method of computing the utilization of the absorbed nitrogen may be illustrated by considering the data for rat 133, period 2. This rat consumed per day an average of 48.2 mgm. of nitrogen and excreted in the feces an average of 21.2 mgm.

TABLE 2

Percentage composition of experimental rations

CONSTITUENT	RATION*								
	1	2	3	4	5	6	7	8	9
Coconut meal	24.0			48.0			24.0		24.0
Rice bran								85.6	42.8
Soy bean		11.9			23.8	11.9			
Corn			60.5			60.5	57.8		
Starch	56.0	68.1	19.5	32.0	56.2	7.6			15.2
Agar	2.0	2.0	2.0	2.0	2.0	2.0			
Sucrose	5.0	5.0	5.0	5.0	5.0	5.0	5.2	1.4	5.0
Butterfat	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Salts	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nitrogen content	0.897	0.919	0.957	1.704	1.743	1.782	1.768	1.694	1.687

*Osborne and Wakeman's preparation of Vitamin B was added to rations 1, 2, 3, 4 and 5 at the rate of 170 mgm. per 100 grams of ration.

Of the latter loss, however, the body of the rat contributes some, estimated at 9.8 mgm. (column d) from the data from periods 1 and 8. Hence the daily feces contained 21.2 − 9.8 = 11.4 mgm. of food nitrogen. The amount of digestible nitrogen consumed per day was, therefore, 48.2 − 11.4 = 36.8 mgm. The daily excretion of urinary nitrogen was 22.0 mgm., but this also is partly derived from the body and partly represents a wastage of food nitrogen. The loss from the body, the endogenous nitrogen, is estimated from the urinary losses in periods 1 and 8 as being 11.7 mgm. Hence the food nitrogen wasted in the urine is 22.0 − 11.7 = 10.3 mgm. per day. Therefore, of the

TABLE 3

The utilization of the proteins of coconut meal, soy bean and corn fed at a level of 5 per cent

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N
Coconut meal ration 1											
		grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*
131	2	65.5	71.5	6.96	62.4	27.5	26.2	11.6	18.6	38.9	81
132	2	42.5	45.0	4.06	36.4	16.7	15.2	8.0	8.5	21.0	72
133	2	58.5	60.0	5.37	48.2	22.0	21.2	9.8	11.7	26.5	72
131	3	71.5	69.0	5.19	46.6	24.1	19.7	9.4	18.8	31.0	85
132	3	45.0	48.0	4.09	36.7	16.4	13.5	8.1	9.0	23.9	76
133	3	60.0	62.0	5.13	46.0	21.6	17.7	9.3	12.3	28.3	75
Average											77
Soy bean ration 2											
134	2	69.0	81.0	8.13	74.7	30.0	14.7	9.0	16.1	55.1	80
135	2	52.5	60.5	5.81	53.4	21.6	11.8	12.6	8.7	40.5	76
136a	2	76.0	72.0	4.60	42.3	27.8	16.8	13.0	15.2	25.8	(67)*
134	3	81.0	75.5	4.78	43.9	26.0	11.8	5.5	15.7	27.3	(73)*
135	3	60.5	56.0	3.54	32.5	23.5	9.8	7.4	8.6	15.2	(50)*
136a	3	72.0	71.5	3.97	36.5	32.2	14.1	11.2	14.7	16.1	(48)*
Average											78
Corn ration 3											
137	2	47.5	45.0	3.97	38.0	18.6	13.5	7.2	8.1	21.2	67
138	2	63.0	71.5	6.55	62.7	28.3	16.5	12.8	13.0	43.7	74
139	2	50.5	51.5	5.19	49.7	22.3	16.2	11.8	10.7	33.7	74
137	3	45.0	49.5	4.33	41.4	21.1	11.0	7.8	8.2	25.3	66
138	3	71.5	77.5	6.77	64.7	27.8	18.5	13.6	13.9	45.9	77
139	3	51.5	54.0	5.17	49.5	23.0	14.7	11.8	10.7	34.3	74
Average											72

* These values are not included in the average because the food intake of these periods was obviously inadequate to cover the energy requirements.

36.8 mgm. of coconut nitrogen absorbed, only 36.8 − 10.3 = 26.5 mgm., or 81 per cent, is retained for maintenance and

growth. This percentage is taken as a measure of the biological value of coconut protein at this level of intake for this particular rat and period. It is to be noted especially that the values in column f are not equal to the nitrogen balance as ordinarily computed.

The experimental data for coconut meal and for corn are satisfactory, since the rations were in general consumed in sufficient amounts to maintain weight. The average utilization of the coconut meal protein was 77 per cent and of corn 72 per cent. The individual values, however, were not sufficiently consistent to warrant the conclusion that the proteins of the coconut are of higher biological value than the proteins of corn.

The results with the soy bean ration were unsatisfactory except for two periods, i.e., period 2 for rats 134 and 135. In all other periods the food intake was obviously insufficient and low utilization of the nitrogen could not be attributed only to the chemical characteristics of the protein. The percentages obtained for the two exceptional periods were 80 and 76, averaging 78.

There are no grounds for believing, therefore, that these three types of food protein have distinctly different values in nutrition aside from differences in digestibility, when fed at this low level.

RESULTS WITH MEDIUM PROTEIN RATIONS

In most of our metabolism experiments on rats we have been able to get more concordant results and hence more satisfactory results with rations containing approximately 10 per cent of protein than with our 5 per cent rations, mainly because such rations are consumed in larger quantities and keep the rats in better condition. This level of protein intake is, however, not high enough to support maximum growth, at least when the protein is of vegetable origin, so that the results of the nitrogen balance studies will not be vitiated by the consumption of protein in amounts above the body's requirements, and by the utilization of protein primarily for energy production.

In table 4 are included the results of balance studies on the proteins of coconut meal, soy beans, and corn fed in rations containing approximately 10 per cent of protein. With the excep-

TABLE 4

The utilization of the proteins of coconut meal, soy bean, and rice bran fed at a level of 10 per cent

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N
Coconut meal ration 4											
		grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*
131	4	71.5	78.0	6.36	108.4	50.3	42.0	12.6	19.7	48.4	61
132	4	50.5	50.0	4.74	80.8	37.4	33.9	9.3	9.7	28.5	51
133	4	64.0	70.0	5.79	98.7	43.1	38.3	10.5	13.9	41.7	59
131	5	78.0	83.0	7.31	124.6	55.0	51.1	15.6	20.4	54.5	61
132	5	50.0	55.0	4.74	80.8	35.0	32.0	9.3	10.2	33.3	57
133	5	70.0	72.5	5.95	101.4	44.9	39.6	10.8	14.7	42.4	58
Average											58
Soy bean ration 5											
134	4	80.5	95.5	7.59	132.3	56.2	22.5	9.2	16.4	79.2	67
135	4	60.5	69.5	5.74	100.0	44.8	18.2	11.5	9.0	57.5	62
136a	4	72.0	69.0	3.49	60.8	46.8	19.5	9.9	14.5	18.9	(37)
134	5	95.5	109.0	8.07	140.6	62.8	21.3	10.1	17.6	84.2	65
135	5	69.5	83.0	7.20	125.5	54.0	22.5	13.9	10.0	72.9	62
136a	5										
Average											64
Rice bran ration 8											
134	6	112.5	130.0	11.84	200.6	66.5	81.8	16.1	19.2	87.6	65
135	6	91.5	105.0	11.18	189.4	61.5	80.6	20.7	12.1	80.1	62
136b	6	137.5	150.0	12.57	212.9	71.7	98.4	34.6	19.9	90.3	65
134	7	130.0	146.5	12.50	211.7	59.1	93.5	17.0	19.9	95.9	71
135	7	105.0	126.0	13.02	220.6	59.1	94.7	23.0	13.4	103.2	70
136b	7	150.0	166.0	13.34	226.0	65.6	108.7	36.8	21.8	110.3	72
Average											67

tion of the one period for rat 136a on the soy bean ration, the results of all periods were satisfactory. For coconut meal, the results for the six balance periods were remarkably concordant,

TABLE 5

The utilization of the proteins of corn, coconut meal, soy bean and rice bran fed in various combinations at a level of 10 per cent

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N
				Corn plus soy bean ration 6							
		grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*
137	4	53.0	65.0	6.29	112.1	45.2	16.3	11.4	10.3	72.3	67
138	4	82.0	93.5	7.81	139.2	59.7	29.4	15.7	15.5	81.3	65
139	4	59.0	64.5	5.75	102.5	44.7	24.7	13.1	12.1	58.3	64
137	5	65.0	74.0	7.31	130.3	50.7	30.0	13.2	12.1	74.9	66
138	5	93.5	101.0	6.95	123.8	51.8	29.4	14.0	16.3	72.9	67
139	5	64.5	70.0	5.67	101.0	43.6	25.8	12.9	12.7	57.2	65
Average											66
				Coconut meal plus corn ration 7							
131	6	85.0	104.0	9.55	168.8	82.8	47.7	22.0	24.0	84.3	59
132	6	60.0	66.0	5.94	105.0	52.4	31.2	11.7	12.3	45.4	53
133	6	75.5	87.0	7.67	135.6	65.2	36.8	14.0	18.0	65.6	58
131	7	104.0	108.0	8.30	146.7	73.7	46.2	20.4	26.3	73.5	61
132	7	66.0	71.5	6.11	108.0	51.5	34.3	12.0	13.4	47.6	56
133	7	87.0	95.0	7.32	129.4	59.8	41.0	13.3	20.2	62.1	61
Average											58
				Rice bran plus coconut meal ration 9							
137	6	72.5	90.0	8.94	150.8	51.5	61.6	16.2	14.1	68.0	65
138	6	101.5	115.0	9.35	157.7	62.1	60.0	18.8	17.3	71.7	62
139	6	73.0	80.0	8.26	139.3	49.9	71.0	18.8	13.9	51.1	59
137	7	90.0	96.0	9.02	152.2	46.8	75.7	16.3	16.2	62.2	67
138	7	115.0	130.0	11.41	192.5	66.9	84.9	22.9	18.4	82.0	63
139	7	80.0	89.0	8.99	151.7	54.1	73.8	20.5	14.8	59.1	60
Average											63

the average utilization coefficient being 58. For the four soybean periods, the results agreed fairly well, averaging 64, all percentages being above 60. For the rice bran ration, the first

three periods (6) agreed well among themselves, but the next three periods (7) were all distinctly higher than the first three. The average for all six periods was 67 per cent.

From these results it would seem that the proteins of coconut meal are slightly but distinctly less efficient than the proteins of soy beans for structural purposes in the body of the rat. A distinct difference between soy bean proteins and rice bran proteins is not so clear, though our results do favor the latter.

In table 5 are given data obtained on rations containing proteins from two sources, approximately half of the protein coming from each of the constituent foods. The total protein content of these rations closely approximated 10 per cent. In other tests in this laboratory we have shown that corn protein alone, fed at this level, has a biological value somewhere between 50 and 60, in most tests approximating to 60. In table 5 it will be seen that a mixture of proteins from coconut meal and corn has a value of 58 on the average, so that no supplementary effect of the proteins of these two feeds appears to exist. Soy bean and corn proteins have an average value of 66. This may indicate a slight supplementing effect of one source of protein on the other, though the data are too few to permit a definite statement to this effect. Rice bran and coconut meal proteins, mixed in equal proportions, have an average value of 63, exactly midway between the average values of the unmixed proteins, i.e., 58 for coconut meal and 67 for rice bran. In this case, therefore, there is no reason to suspect any supplementary effect, that is, an improvement in the quality of the proteins of one feed by mixture with the proteins of another feed.

These tests on mixed rations are in line with the general experience of this and other laboratories, that vegetable proteins do not exhibit striking supplementary effects on one another. It is only when animal proteins are mixed with vegetable proteins that such effects are to be expected.

THE NET PROTEIN VALUES OF FEEDS

By the combined use of average percentages of total protein in feeds, average digestion coefficients, measuring the wastage

of protein in digestion, and average biological values, measuring the wastage of protein in metabolism, it is possible to compute what might well be termed the "net protein" content of feeds. Such computations are illustrated by the values given in table 6. The percentages of digestible protein are taken from Henry and Morrison's tables for ruminants, and the biological values of the proteins are taken from this investigation and that of Nevens previously referred to, with the exception of the value for corn which is the average of a large number of trials with rations containing approximately 10 per cent of protein.

TABLE 6

FEED	CONTENT OF DIGESTIBLE PROTEIN	BIOLOGICAL VALUE OF DIGESTIBLE PROTEIN	CONTENT OF NET PROTEIN
	per cent	*per cent*	*per cent*
Corn	7.5	58	4.3
Rice bran	7.9	67	5.3
Soy beans	30.7	64	19.6
Coconut meal	18.8	59	11.1
Cottonseed meal	37.0	66	24.4
Alfalfa hay	10.6	62	6.6

The use of net protein values may be illustrated as follows: A 1000 pound cow requires for maintenance, say 0.5 pound of protein per day. She produces daily 30 pounds of milk containing 3 per cent of protein, or 0.9 pound of milk protein. Her daily protein requirement therefore is 1.4 pound. Now alfalfa hay contains 6.6 pounds of net protein per 100 pounds. Therefore, $(1.4 \div 6.6) \times 100 = 21.2$ pound of alfalfa hay daily would be required to keep her in nitrogen equilibrium. If enough of a grain mixture containing 3 parts corn, 1 part rice bran, and 1 part cottonseed meal, is to be fed to cover the protein requirements of milk production, the calculation would be:

$$0.9 \div \{(3 \times 4.3 + 5.3 + 24.4) \div 5\} \times 100 = 10.6 \text{ pounds}$$

Such calculations assume, of course, that no considerable supplementing effect of the proteins of one feed upon those of another occurs, and that the biological values of digestible pro-

tein obtained with rats have a wide applicability to other species of animals and to other physiological functions than growth and maintenance. The first assumption is probably perfectly justified. Whatever slight supplementary effect may occur would enhance the value of the protein and hence the calculation would give results slightly higher than the actual requirement. The estimated allowance of feed would therefore always be a safe one if this were the only possible error involved.

The second assumption is, of course, open to considerable question. As far as differences between species are concerned we have recalculated some nitrogen balance results published at Wisconsin on pigs and have obtained biological values for corn ranging from 48 to 60, quite analogous to those we have obtained with rats, and biological values for the mixed proteins of milk of 80 to 85, again checking closely our values with rats. We know of no data on other species sufficiently complete to permit of comparison with our data on rats. That the value of a food protein in the elaboration of the proteins of milk may be significantly different from its value in maintenance and growth seems probable, though until information on the former point is available, a calculation such as that given above may be considered a good first approximation to the truth. More confidence, of course, can be felt in such computations applied to maintenance and growth requirements, than to milk requirements.

For example, according to Armsby a dairy calf one year old and weighing 400 pounds requires daily 0.24 pound of digestible protein for maintenance and when gaining at a maximum rate puts on 0.14 pound of protein daily. The former figure is probably somewhat high as a measure of the break-down of body tissues per day. It is certainly a safe estimate of the need for protein for maintenance. Taking it in this sense, we may say that the total protein requirement of the calf is 0.38 pound per day. If the calf is raised on alfalfa hay, it will require per day $0.38 \div 0.66 = 5.76$ pounds to provide the required amount of protein. Since a calf of that size and age will require some 15 pounds of alfalfa hay to cover its energy requirements, according

to Armsby's growth standard, the consumption of this much hay will evidently provide ample protein for growth. In fact, half the hay could be replaced by an amount of corn equivalent to it in net energy (i.e., 3 pounds) without fear of restricting growth by an insufficient supply of protein.

EFFECT OF AUTOCLAVING ON VITAMIN CONTENT IN MILK

E. J. SLANETZ

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Received for publication February 6, 1923

Whether or not the vitamin of milk are destroyed by pasteurization or sterilization has been the subject of much debate during recent years. Inasmuch as milk is a perfect food, containing all the nutriments required by a growing body in proper proportion and in palatable and digestible form, its vitamin content deserves special consideration.

Feeding experiments were carried on to determine how the fat-soluble A vitamin and the water-soluble B are affected by heating. The C vitamin, or the antiscorbutic vitamin, is not necessary for the growth of the animals (mice) used in the experiments as this vitamin is synthesized by them.

Milk was autoclaved at ten pounds pressure for fifteen minutes and fed to growing mice which had been fed for a period of about fifteen days on a diet devoid of vitamins, but complete in respect to protein, carbohydrates, fats and minerals.

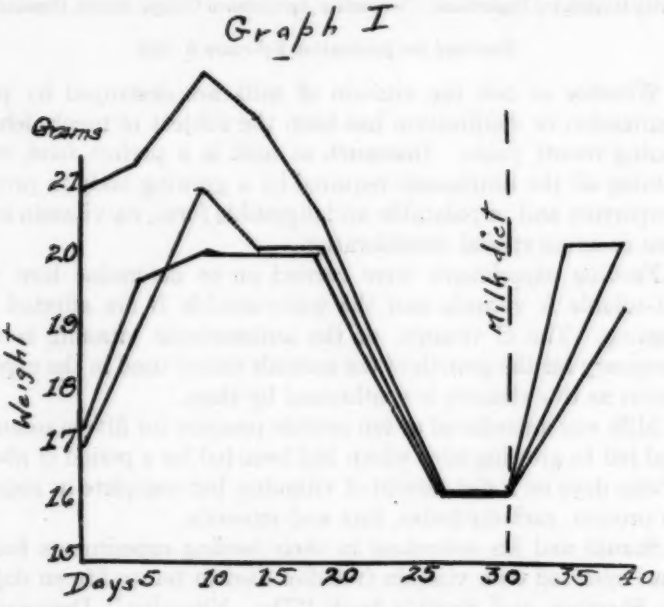
Suzuki and his coworkers in their feeding experiments found that mice fed on a vitamin free diet died in ten to fifteen days.[1] In Sherman and Smith's book "The Vitamins," Drummond states, "The length of time that an animal is able to maintain itself on a diet deficient in B without suffering serious loss of body weight appeared to be directly proportional to the age, at which the restriction is imposed" (p. 44).

In case of the A vitamin the animal may cease to grow, or continue slowly or may continue for a longer or shorter period depending upon the store of vitamin A in the body of the animal at the beginning of the experiment and the food consumption of the animal.[2]

[1] Sherman and Smith, "The Vitamins," p. 27.

[2] However, the age of the animal is also worthy of consideration.

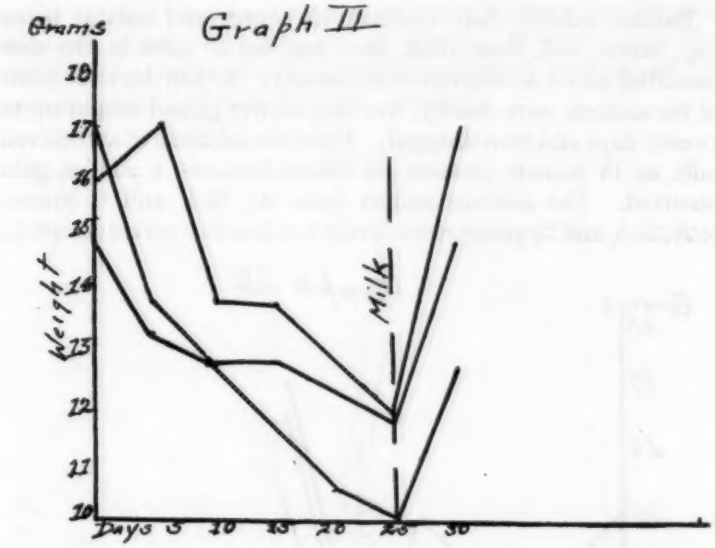
The results on graph 1 show that on the addition of milk two 17 gram animals put on 4 grams each in a five-day period. Evidently the heating of milk at 10 pounds pressure for fifteen minutes does not destroy to any appreciable extent the B vitamin content. A vitamin was supplied in the basal diet.

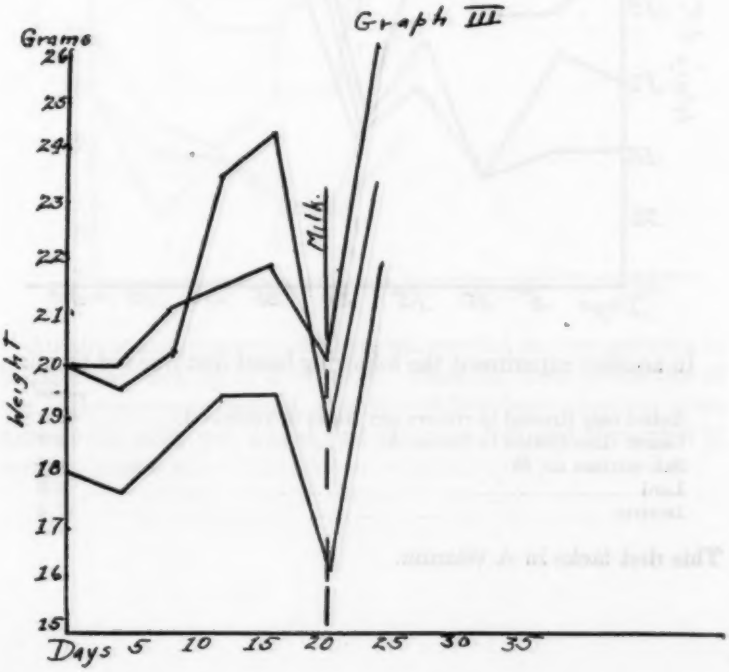


Basal diet (lacking in B vitamin)

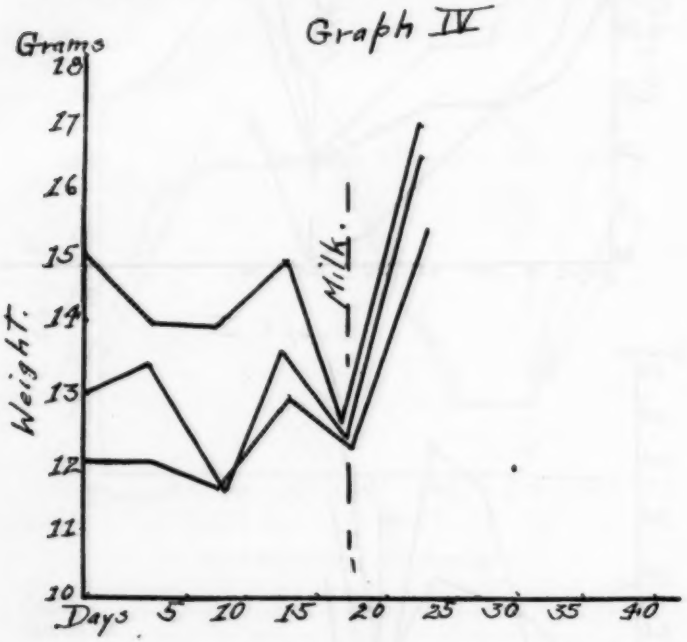
	per cent
Casein	18.
Salt no. 35	3.7
Dextrin	71.3
Butterfat	5.0
Agar	2.0

Another experiment was conducted using milk heated at 15 pounds pressure for fifteen minutes. Here again the graph 2 shows remarkable growth upon the administration of milk after a decline in weight for a period of twenty-five days on a basal diet as described above.


Graph II
Grams
Weight
Milk
Days 5 10 15 20 25 30


Graph III
Grams
Weight
Milk
Days 5 10 15 20 25 30 35

Bacillus subtilis (hay bacillus), its source and habitat being hay, straw, soil, dust, milk, etc., was fed to mice in the diet described above to determine its toxicity. At ten days the coats of the animals were shabby, but they slowly gained weight up to twenty days and then dropped. Upon the addition of autoclaved milk at 15 pounds pressure for fifteen minutes, a sudden gain occurred. The animals gained from 20, 18.5, and 16 grams, to 26, 23.5, and 22 grams respectively in a five-day period (graph 3).

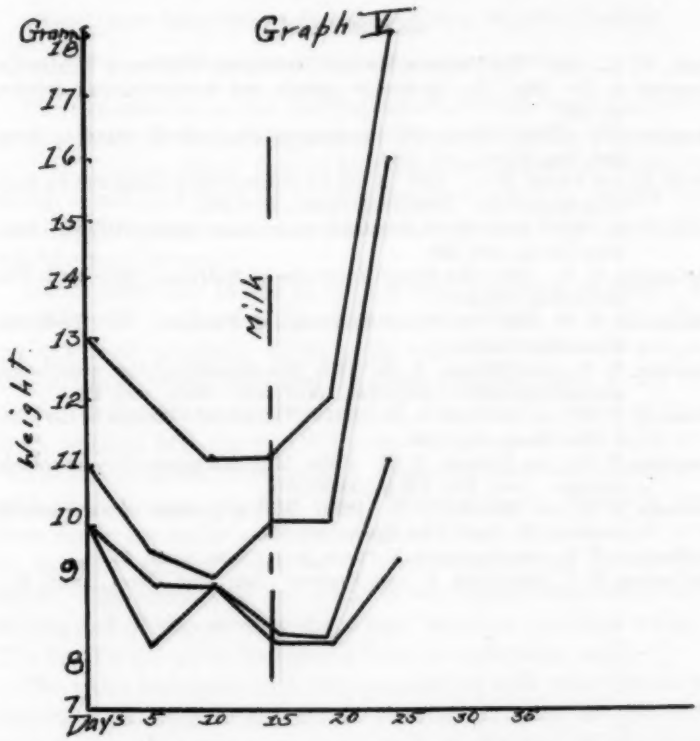


In another experiment the following basal diet was fed to mice.

	per cent
Rolled oats (treated to remove any traces of vitamin A)	40.0
Casein (also treated to remove A)	5.0
Salt mixture no. 35	2.5
Lard	5.0
Dextrin	47.5

This diet lacks in A vitamin.

The animals begain to show signs of xerophthalmia (eye disease) at about sixteen days and loss of weight. However upon the addition of autoclaved milk three to five grams were gained by each animal in a five-day period (graph 4).



An abundant growing soil organism was fed to younger mice in a basal diet lacking in B vitamin. Here the toxic properties of the organisms were marked, since it took five days to recover when autoclaved milk was added and this was followed by a gain in weight (graph 5).

CONCLUSIONS

The fat-soluble A and water-soluble B of milk autoclaved at 10 pounds pressure, and 15 pounds pressure for 15 minutes are not affected to any appreciable extent when fed as a source of vitamin.

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THE OPTIMUM QUANTITY OF SKIMMILK FOR CALF FEEDING

T. E. WOODWARD

United States Dairy Division Experiment Station, Beltsville, Maryland

Received for publication November 27, 1922

The experiment on calf feeding reported below was conducted at the Dairy Division Experiment Farm, Beltsville, Maryland, and had for its object, first to find out the quantity of skimmilk which would give the best results as regards gains in weight and economy of gains; second to find out if feeding large quantities would cause scours.

There were four calves in each group, balanced as nearly as possible with reference to breed and body weight at birth. One group was given a daily ration, at the rate of $\frac{1}{7}$ of the body weight, the quantity being regulated by body weights taken every ten days. Two other groups were fed at the rate of $\frac{1}{6}$ and $\frac{1}{8}$ of their body weights and the fourth group was given all the milk the calves would drink, twice a day. Each calf received its mother's milk until it was ten days old. The change to skimmilk was then made gradually and at the age of fifteen days the calf was on an entire skimmilk ration. The experiment ran for seventy days. The average of the weights for three consecutive days at the end of the seventy days was taken as the final weight. The results are given in tabular form on following page.

The gains increased with the quantity of milk fed, the calves receiving all they would drink, making at least 50 per cent larger gains than those receiving milk at the rate of $\frac{1}{7}$ of their body weight. To do this they drank about 80 per cent more skimmilk. As a result the milk required per one pound of gain was greater with the heavily fed calves, although it will be observed that the results are not entirely consistent in this respect. Apparently the calves which received all the milk they would drink made gains more economically than those fed at the rate of $\frac{1}{8}$ of the body weight.

Satisfactory gains were made by feeding skimmilk at the rate of $\frac{1}{7}$ of the body weight. Whether or not more than this is to be

Gains in weight made by calves on various quantities of skimmilk

CALF NUMBER	BREED	BIRTH WEIGHT	FINAL WEIGHT	DAYS ON EXPERIMENT	TOTAL GAIN	DAILY GAIN	TOTAL MILK CONSUMED	MILK PER DAY	MILK PER POUND GAIN
Fed at the rate of $\frac{1}{7}$ of body weight									
		pounds	*pounds*		*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
59	Gr. Hol.	64	130.0	70	66.0	0.94	902.0	12.89	13.7
213	P. B. Hol.	98	182.0	70	84.0	1.20	1266.0	18.09	15.1
67	Gr. Hol.	56	129.5	70	73.5	1.05	859.5	12.28	11.7
70	Gr. Guer.	63	107.0	70	44.0	0.63	757.7	10.82	17.2
Average.....		70.2	137.1		66.9	0.95	946.3	13.52	14.2
Fed at the rate of $\frac{1}{8}$ of body weight									
57	Gr. Guer	68	141.0	70	73.0	1.04	1142.0	16.31	15.6
60	Gr. Guer.	62	138.0	70	76.0	1.09	1046.0	14.94	13.8
64	Gr. Hol.	85	164.0	70	79.0	1.13	1305.0	18.64	16.5
215	P. B. Hol.	85	161.0	70	76.0	1.09	1264.9	18.07	16.6
Average.....		75.0	151.0		76.0	1.09	1189.5	16.99	15.7
Fed at the rate of $\frac{1}{9}$ of body weight									
58	Gr. Guer.	58	149.0	70	91.0	1.30	1279.0	18.27	14.1
118	P. B. Guer.	77	147.0	70	70.0	1.00	1472.0	21.03	21.0
63	Gr. Hol.	70	185.0	70	115.0	1.64	1659.5	23.71	14.4
214	P. B. Hol.	83	161.0	70	78.0	1.11	1457.2	20.82	18.7
Average.....		72.0	160.5		88.5	1.26	1466.9	20.96	16.6
Fed all they would consume twice daily									
18	Gr. Hol.	89	221.0	70	132.0	1.89	1973.0	29.19	14.9
106	P. B. Guer.	84	200.0	70	116.0	1.66	1898.0	27.11	16.4
110	P. B. Guer.	68	163.0	70	95.0	1.36	1539.0	21.99	16.2
68	Gr. Guer.	57	129.0	70	72.0	1.03	1372.0	19.60	19.1
Average.....		74.5	178.2		103.7	1.48	1695.5	24.22	16.3

given will depend upon the rate of growth desired and upon the quantity of skimmilk available. Rather than throw away the skimmilk it would be better to feed it to the calves even if the larger quantities are not utilized so economically.

No bad results from heavy feeding were noticed, although all of the calves in group four, except no. 68, drank at times more than 40 pounds of skimmilk a day. This would indicate that overfeeding in itself is not a common cause of scours.

AN EXPERIMENT MANGER

ANDREW C. McCANDLISH AND FORDYCE ELY

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Received for publication July 25, 1922

One of the difficulties in conducting feeding or digestion trials with cows is in having a suitable manger. For these purposes the manger should prevent wastage of feed due to the cows throwing it over the top of the manger in front of them or drawing it towards them among the bedding. In addition, cows should be prevented from stealing feed from each other.

A manger which has been in use in the Dairy Husbandry Section of the Iowa Agricultural Experiment Station for the last four years has been found very satisfactory. Sections of it are shown in figure 1.

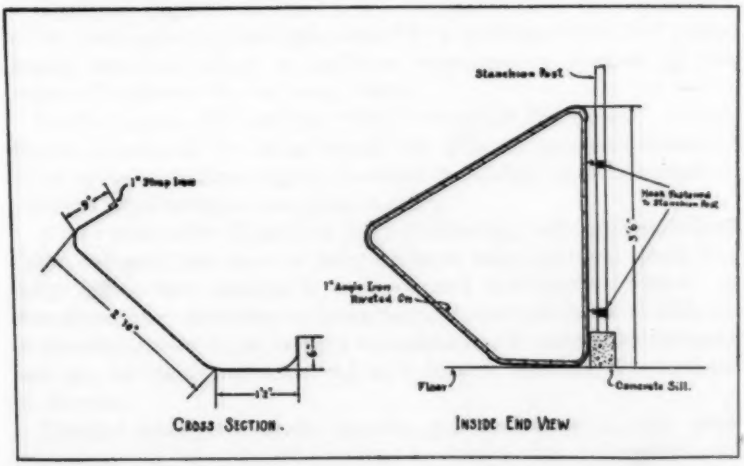

FIG. 1 DETAILS OF AN EXPERIMENT MANGER

It is constructed of galvanized iron with one-inch angle iron for joining the ends to the main body and the flange turned up in front is supported with 1-inch strap iron. On the stanchion post at each end of the manger there are two hooks. Each hook and its attachment consists of two pieces of 2-inch strap iron which are bolted around the stanchion post and the end of one of the pieces in each pair is extended and formed into a hook. Eyes to correspond are on the manger ends. The inner edge is level with the top of the 6-inch concrete sill in which the stanchion posts are set, and the concrete sill aids in the prevention of feed being wasted among the bedding.

All corners in the mangers except where angle iron is used are rounded and this tends to keep the mangers clean. From the base of the sill to the front of the manger at the base is 14 inches. From there the front slopes upward at an angle of 45 degrees and then curves round more rapidly and the top of the manger extends inwards for 9 inches.

The length of the mangers in use is 40 inches but they can be made of any length to suit the distance between the stanchion posts.

BOOK REVIEW

The Technical Control of Dairy Products by Timothy Mojonnier and Hugh Charles Troy is a real attempt to assemble an extensive treatise on the testing, analyzing and standardizing of dairy products and the manufacture of ice cream, condensed and evaporated milks. Beginning with a description of the dairy plant laboratory and its equipment a detailed technical discussion of the average composition of milk and the nature of milk constituents is presented in the form of an introduction into the field of dairy manufacturing.

In subsequent six chapters are given precise directions and pointed precautions in regards to sampling and testing various dairy products for butterfat and total solids. A brief history of the various tests for butterfat is related and emphasis is made regarding the Mojonnier butterfat test or the modified Röse-Gottlieb method as employed in connection with the Mojonnier Tester.

Several methods of standardizing milk, cream and condensed milks for butterfat and solids not fat plus detailed calculations for condensed milks are illustrated by formulas of typical problems and by the aid of extensive tables.

A special chapter is devoted to the composition and standardization of ice cream mixes and is supplemented by a set of problems and painstaking compiled tables to facilitate computations involved in the standardization of the ice cream batch.

Under Chapter XV entitled "The Overrun in Ice Cream" various factors influencing the same through the different processes employed in ice cream manufacturing are discussed in the light of facts learned in different experiments on ice cream making.

A very instructive chapter on dairy bacteriology with explanations of "starters" and their uses in dairy products offers material which has never before been brought in such compact and practical shape. A chapter on dairy chemistry covering the most practical chemical analyses of constituents employed in dairy manufacturing is very comprehensive and can be highly recommended as a reliable reference to students in dairying.

Detailed description of the vacuum pan and a simple and clear presentation of the manifold problems involved in the processes of condensing milk and methods of sterilizing evaporated milk is a prominent feature of this treatise.

Essentials pertaining to milk inspection and scoring of various dairy products followed by definitions and standards for dairy and related products are conspicuously displayed.

The last Chapter XXII gives diagrammatic illustrations of flow sheets of various phases of dairy manufacturing; indicates temperatures for holding, processing, and storing dairy products; it also gives a discussion relating the properties of metals and alloys and their effects on milk.

There are useful tables in the appendix and at the end of each chapter a bibliography of references is given to indicate the source of information on the various problems discussed in each chapter of the book. The systematic arrangement of the tables and illustrations in connection with a clear expression of rather technical matter makes it easily comprehended by the nontechnical reader as well as the dairy expert. This book provides valuable information to the dairy technologist, the ice cream maker, the manufacturer of condensed and evaporated milks as well as to the creamery man and student in dairy manufacturing. It may be considered a worth while attempt to furnish the dairy manufacturer with a reference book somewhat similar in nature to Henry's "Feeds and Feeding" used by the stockman, the production man.

BENJAMIN MASUROVSKY,
Lincoln, Nebraska.

FRITZ WILHELM WOLL

Dr. Fritz Wilhelm Woll, Professor of Animal Nutrition, University of California, well known as a writer on animal feeding and dairy subjects, died at Berkeley, Calif., December 6, 1922.

Dr. Woll received his early education in Christiania, Norway, obtaining the degree of Bachelor of Philosophy from the Royal Fredericks University, Christiania, in 1883. Degrees of Master of Science and Doctor of Philosophy were conferred by the University of Wisconsin in 1886 and 1904, respectively. In 1887, Dr. Woll was appointed second Assistant Chemist, Wisconsin Agricultural Experiment Station, rising to Chemist for the Station in 1897. He became Professor of Agricultural Chemistry, University of Wisconsin, in 1906, which position he held until 1913, when he was called to the University of California as Professor of Animal Nutrition, holding that chair until his death.

Dr. Woll was the author of many works, which have been reissued in a number of editions; among these may be mentioned the following:

A Book on Silage, revised edition, 1900;

A Translation of Modern Dairy Practice (From Swedish of G. Grotenfelt) 1894—3rd edition, 1905;

A Handbook for Farmers and Dairymen, 1897—6th edition, 1914;

Testing Milk and Its Products (with Professor E. H. Farrington) 1897—24th edition, 1918;

Productive Feeding of Farm Animals, 1915—2nd edition, 1916—3rd edition, 1921; and

Feed Manual and Note Book, 1917.

While at the Universities of California and Wisconsin Dr. Woll accomplished a large amount of scientific work. This is shown by the series of important and timely bulletins of the respective agricultural experiment stations. He was also an extensive contributor to technical publications and agricultural and dairy papers. His articles were always replete with valuable aid to dairymen and feeders in general.

It is owing, primarily, to the untiring efforts of Dr. Woll that cow-testing associations, which proved of so much value and importance to the dairy industry of California, were developed and placed on a business-like and permanent basis.

Dr. Woll was a member of many agricultural and scientific societies, including Wisconsin Academy of Sciences, Arts and Letters; Society for the Promotion of Agricultural Science; American Society for Animal Production; Association of Official Agricultural Chemists (president, 1909–11); American Dairy Science Association; Sigma XI; International Jury Panama Pacific International Exposition, 1915.

The passing of Dr. Woll is a great loss to the University of California and to the animal industry of the whole country.

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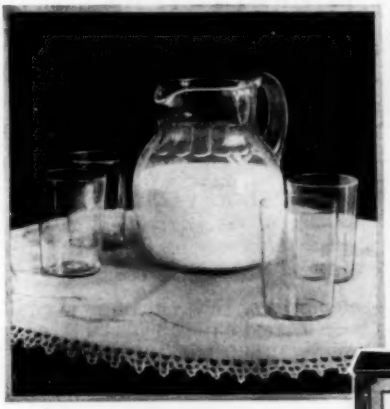

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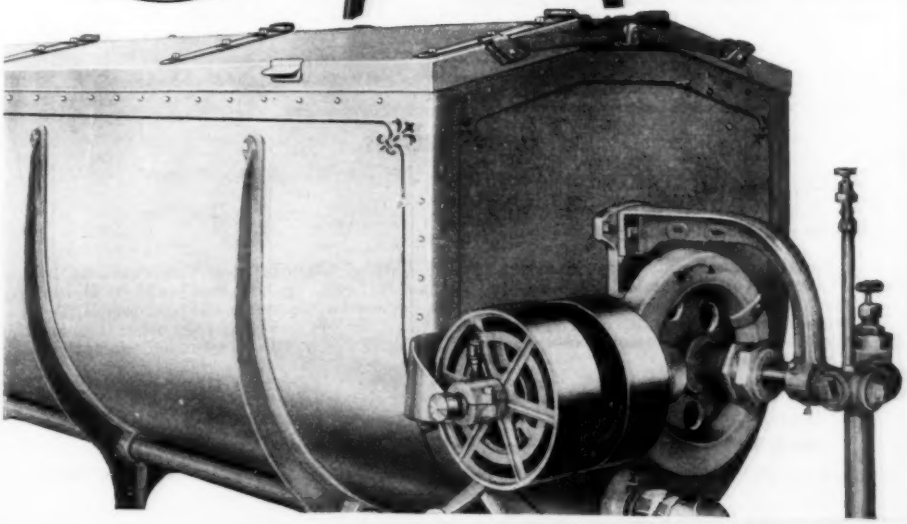

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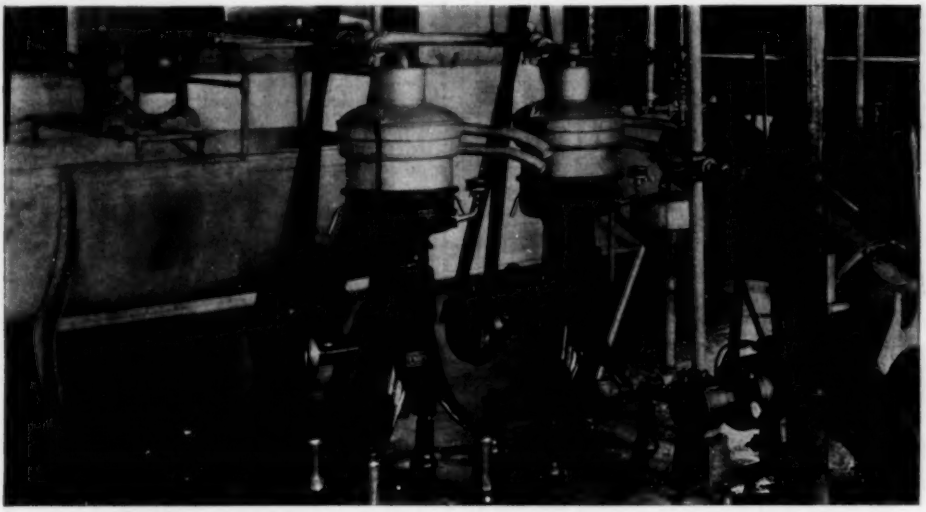

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